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IN ENGLISH TRANSLATION

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PLANT LABORATORIES IN 1957

What work do plant laboratories do? The editors put this question to some central laboratories of iron and steel plants. The answers of several plant laboratory managers are published below.

Contribution by N. I. Beda (Manager of Central Plant Laboratories of the Petrov Plant).

At our plant, a new experimental blast furnace of 8 m^3 capacity will be built. Together with the Ukrainian SSR Academy of Sciences' Institute of Ferrous Metals and the Dnepropetrovsk Metallurgical Institute, we shall experiment on this furnace with the feeding of oxygen through a special nozzle to the center of the hearth with the object of increasing the activity of the gas stream in the center of the furnace. Coke oven or natural gas will also be blown into the furnace experimentally.

On the same pilot plant, a new method of heating the hot blast stoves will be tried which is intended to ensure uniform heating of all the brick checker work to an average temperature of 800 to 900°C. This enables thermal conditions in the stoves to be improved.

The blast furnace group of the central laboratories of the Petrov Plant, together with the Dnepropetrovsk Metallurgical Institute, is working on problems of the desulfurization of pig iron outside the blast furnace. Economically, this is the most profitable method of obtaining pig iron of low sulfur content. We wish to replace the expensive soda with a cheap desulfurizer – lime. The mastering of desulfurization outside the furnace makes it possible to increase the acidity of slags and to lower coke consumption.

The converter group of the central plant laboratories, in cooperation with TsNIIChM (Central Scientific Research Institute of Ferrous Metallurgy), is working on the perfecting of a process of blowing open hearth pig iron in a basic converter with pure oxygen. Our plant was the first in the Soviet Union to perfect this new process of steel production on an industrial scale. In contrast to normal methods of converter production – acid and basic Bessemer processes – much heat is evolved because of the absence of nitrogen in the converter gases. In foreign plants, this heat is utilized for remelting scrap added to the pig iron in amounts up to 30% by weight of hot metal.

At our plant, another process has been developed and perfected in which iron ore is added to the pig iron while oxygen is fed together with a water spray. With the object of avoiding the action of the silica of the ore on the basic lining of the converters and of preventing an increase in slag bulk, modified processes using low silicon hearth cinder and specially prepared ore-limestone briquets are being investigated at the suggestion of the Ukrainian Institute of Metals. Preliminary experiments in the use of the briquets produced good results. The influence of the quantity of atomized water on the process is being examined.

The problem of increasing the yield of good metal has received great attention in the work of the central plant laboratories. At the early states of these investigations, metal was frequently ejected from the converters and escaped with the slag during dephosphorization. Today, metal yield approaches the best figures obtained in foreign plants. A further increase in metal yield will be attained by perfecting the technology of decanting the hot metal and improving slag control.

We must, this year, draw up standard technological instructions for the top blowing of open hearth pig iron in the basic converter so that this process can be perfected at all other plants.

We shall also work on improving the life of the converter linings. During the initial operational period of oxygen blowing in the acid converter plant, converter life was very low (averaging 33 heats) while the consumption

of chrome-magnesite and magnesite-chrome brick for the fourth quarter of 1956 and 36 kg per ton of steel. It was essential to find a brick capable of withstanding the very high temperatures (e. g., 2500°C according to TsNIIChM data) which occur when hot metal is blown with oxygen in the converter.

The technique of manufacturing magnesite-chrome PSh type of brick was developed and perfected. Average lining life with this brick for April was 147 heats. Refractory engineers at the plant, together with VNIIO, are continuing their work on a brick with a temperature of intial softening of at least 1800°C.

The open hearth and casting group of the central plant laboratories carried out research work to determine optimum dimensions and shape of ingots and they detailed optimum parameters of temperature and speed of teeming into ingot moulds. The thickness of slab ingots was reduced and the width was increased. While, formerly, the ratio of slab width to thickness was of the order of 1.87 to 2.10, it is now 2.75 to 2.86. The weight of such slab ingots was initially 2 to 2.75 tons. Slab ingots have now been developed with a weight of 3.5 to 3.8 tons.

The change over to slab ingots made it possible to increase the productivity of the plate mill by almost 15% because of the reduction in the number of passes. Crystallization is more intensive in slab ingots and segregation processes develop to a lesser degree. Because of this, the length of the hot top portion is less and cropping is reduced by 1.5 to 2.0%.

In the rolling of sheet, scrap amounts to 2.5 to 3.5% for various reasons but about half is due to laps. With the object of reducing this type of defect, a method was developed for melting low carbon steel with an addition of chromium. Lap defects diminished by about one-third while mill productivity was raised by 12.5%.

The main reason for scrap arising in the rail mills was the necessity for cropping. In order to reduce top discard, a new type of hot top with increased taper was developed. The use of this type of hot top reduced top discard from 15.5 to 14.5% which will save about one million rubles a year.

It was also possible to reduce metal consumption by setting up rationally for shearing and sawing. In setting up, the cutter was fixed to operate so that dead lengths of product are cut and no ends of random length remain. This enabled the consumption coefficient on a rimming steel billet to be reduced from 1.138 in 1955 to 1.121 in the first quarter of 1957. The consumption coefficient in the section mill was of the same order as that for 1955 and even lower for certain sections.

In the first quarter of 1957, metal consumption per ton of tube billet was 1.265 tons which was considerably less than in other southern plants.

We were able to reduce metal consumption in the rolling of 14 KhGS steel sheet by changing over to the use of heavier slabs known as "doubles." The rolling of such sheets is done on profiled rolls – concave in the centers and convex at the ends. This type of profiling is still used only at our plant.

The central plant laboratories metallographic section has been studying the operation of a plate mill. Wear of the bottom forged steel roll of this stand was 250% more rapid than that of the top cast iron roll. This caused a variation in the thickness of the sheets and made frequent roll changing necessary. The metallographic laboratory, with the help of the section mill operators, developed a cast steel roll for the plate mill. Casting reduced wear of these rolls by half. There was a saving of about one million rubles a year. We are presently developing a method of casting the bottom steel rolls for plate mills. A method of casting is being sought in which the hardness of the roll barrel, i. e., the place of maximum wear, is increased.

In setting up for rolling, about 10 to 15% of the billets for the section mill are short and this adversely affects conditions of heating, reduces mill productivity and increases the amount of scrap. In order to ensure that only billets of correct length were supplied to the section mill, it was decided to specify more precisely ingot weight and billet sizes for different sections and to tighten up methods of setting up for cutting. The workers of the rolling laboratory and of the rail mill are working on this problem.

Rod mill operations involve a great deal of manual labor. This means a considerable amount of scrap in the form of cobbles. The use of repeaters in front of the stand for transferring the oval is essential. For this purpose, robust stands with universal spindles and roller bearing will be used. Repeaters must be combined with the roller guides developed and manufactured by the central plant laboratories.

Having investigated the failure of a number of ingot mold designs due to longitudinal cracks at the top, the central plant laboratories suggested a new shape of mold incorporating an inserted cast band or strap and longitudinal ribs on the wide faces which increased mold life by 47%.

The main cause of the failure of open ended slab molds was transverse cracks. At the suggestion of the central plant laboratories, a rib was incorporated on both sides of the wide faces at the points of maximum heating of the molds and this increased mold life by 46%. The design of the closed end mold was also improved by casting on an iron band at the top part of the mold, thus raising mold life by 32%.

Contribution by I. I. Bornatsky, Head of the Central Plant Laboratories of the Kirov Iron and Steel Plant at Makeyevka

With a view to raising the productivity of the sinter machines, the central plant laboratories at Makeyevka carried out some investigations to determine the optimum speed of sinter strands in relation to bed thickness of the sinter burden and to its gas permeability. Questions of ensuring a constant lime (intensifier) contant at 2.5% are also being tackled. A rational method of feeding lime to the burden in the form of slaked lime or milk of lime is being developed.

It is intended to effect a marked increase in the life of the suction fan impellers in the sinter plant by means of gamma relays installed in the dust extracters. Dust will be discharged automatically when a certain level has been reached. This will lower the dust content of the waste gases.

The technology of blast furnace smelting will be improved mainly by raising blast temperature and by smelting pig iron containing 0.8 to 1.2% Mn which enables blast furnace productivity to be raised by 3.5 to 4%. In order to reduce the sulfur, silicon, manganese, and carbon in pig iron, it is intended to carry out trials which involve the blowing of iron with oxygen during tapping.

With the object of further increasing the productivity of large open hearth furnaces, the utilization of oxygen both for enriching the flame and for direct oxidation of the impurities in the metal bath will be improved.

During the last six months of 1957, it is intended to proceed with experimental work on the preparation of pig iron for smelting by blowing it with a steam-oxygen mixture in the hot metal ladles.

To accelerate the process of slag formation and cut the melt-down period, trial heats were produced in open hearth shop No. 1, based on ready-made mixtures of iron ore and limestone. At the same time, a method is being perfected for bunker charging of open hearth furnaces with a mixture of iron ore and limestone.

In cooperation with the Donets Industrial Institute, work is being carried out on the deoxidation of killed steel with ferroaluminum in the ladle. Preliminary data show that, with such a method of deoxidation, the consumption of aluminum can be cut and the ductile properties of the steel can be improved.

It is intended to obtain a further increase in the life of ingot molds by welding up any flaws and crazing in closed end molds and also by using a cast iron with superior heat resisting properties.

In rolling mill No. 1, work has been started on the problem of rolling rimming steel ingots in eleven passes instead of thirteen. A change over to this new scheme of rolling will enable us to increase blooming mill productivity by 8 to 10% when rolling these ingots.

The plant's rolling mills are also solving the question of rolling finished sections in the range from specified dimension to minus tolerance limit and also the problem of unloading metal at the consumer plant according to theoretical weight, which permits a saving of 1.5 to 3.0% of metal.

In cooperation with the Ukrainian Institute of Metals and the Moscow Institute of Steel, the rolling of thin walled sections will be perfected on the 350-1 and 350-2 stands – 40 x 40 x 3 to 50 x 50 x 4 mm angles.

Investigations of the continuous rolling of metal on the 350-2 stand will be carried out by the plant in cooperation with TsNIITMASh (Central Scientific Research Institute for Technology and Engineering). The introduction of continuous rolling increases mill productivity while producing a more stable section and, in addition, chipping is eliminated and improved conditions are created for the mechanical and electrical mill equipment.

The plant is also working towards a reduction of consumption coefficients, on the welding up of worn sheet mill rolls and the building up of blooming mill roll grooves by welding. An x-ray method of inspecting stresses in cast iron sheet mill rolls is being introduced. All rolls received by the plant will be checked for internal stresses and, depending on the extent of these, rolls are put into production or sent to stock for ageing.

New contemporary methods of quality control for raw materials and metal are being introduced in 1957 in the "express laboratories" of the main shops of the plant. Thus, in the sinter plant "express laboratories," a spectral method of determining CaO and SiO_2 in self-fluxing sinter is being introduced which reduces the time required for analysis from 30 to 15 minutes (twice as much in comparison with photocolorimetric methods). The "express laboratory" of open hearth shop No. 2 is perfecting a spectral method for determining silicon in iron on the stylometer whereby the requisite period for analysis is 7 to 10 minutes instead of 45 minutes for the normal chemical method. Open hearth shop No. 1 has also been working on a carbometric method of determining carbon in metal during the progress of a heat.

Contribution by M. T. Bulsky, F. F. Sviridenko and N. T. Berilov (of Azovstal)

In 1957, the central laboratories of the Azovstal Plant have been busy with important problems relating to increased production and improved quality.

The production of self-fluxing sinter from Krivoi Rog and Kerchensk ores with a basicity of 1.3-1.5 and 0.6-0.8, respectively, is being mastered to raise blast furnace productivity by 3 to 5%. The perfecting of smelting technology in the blast furnace will also involve a study of the movement of the burden by means of radioactive isotopes which will also be used to study stack lining wear. In addition, work of major importance has been started on developing integrated automatic control of the blast furnace process.

In the steel-making field, iron ore and limestone, which are at present being added to the charge, must be replaced by sinter or briquet. Sinter with a basicity of 5 to 7 will be produced at our plant from low silicon iron ore which, though it contains a proportion of fines, has a high iron content. Briquets will be obtained from the Krivoi Rog briquet plant. According to data from ten trial heats produced in 1956, the replacement of iron ore and limestone by sinter and briquets enables the phosphorus content on melting to be lowered by 66 to 75%, which is of the highest importance when converting highly phosphoric irons in tilting furnaces. Only one-fifth to one-sixth the amount of millscale is added during melt-down. The melt-down period is cut by 31 minutes and refining, by 28 minutes.

Work is being continued on the blowing of hot metal in ladles with a steam-oxygen mixture. As the trials showed, last year, up to 90% of the silicon, 75% of the manganese, and 30% of the sulfur are oxidized by blowing the hot metal. In addition, it is possible to recover the vanadium in the slag. Large amounts of hot metal (pig iron) will be treated by this method in 1957 and a number of heats will be produced using the preblown metal.

The suggested replacement of the coke-limestone mixture at present used for heating hot tops by exothermic briquets will improve labor conditions by reducing the amount of dust in the pouring assemblies shop and in the pouring bay. At the same time, the amount of top discard will be reduced.

Research is being carried out in an attempt to reduce transverse cracking in rail steel ingots top poured into molds with fixed hot tops. In pouring, corrugations are made on the internal surface of molds to facilitate uniform hanging of the ingot in the top of the mold and to reduce transverse cracking.

In connection with increased axle loading and higher speeds of railroad vehicles at the present time, rail wear is intensified, especially on curves, by the formation of so-called "corrugations." With a view to effecting a 200 to 300% increase in rail life, development work has started at the plant on the production of a heavy rail known as R-75 type (weighing 75 kg per meter). Chromium is also being used as an alloying element in rail steel.

Trials are also being continued on the production of wide-flanged I-beams and joists with thin walls which will permit a 15 to 20% reduction in the weight of the rolled product without any loss in strength.

In order to clarify the possibilities of extending the application of steel having a high arsenic content, a further study will be made of the effect of a high arsenic content of steel on weldability and physical and mechanical properties.

Contribution by N. P. Zhetvin, Research Manager of the Hammer and Sickle Plant in Moscow

Apart from dealing with day-to-day production problems concerned with the perfecting of new grades of steel, new types of production and of rolled sections, the Hammer and Sickle Plant laboratories, in 1957, with the cooperation of plant operatives, has to complete fifteen research projects. We shall here consider the most interesting of these projects.

In 1956, we introduced a method of intensified heating of the feeder head region of ingots of killed grade by means of exothermic mixtures consisting of ground 75% FeSi, fireclay grog and saltpeter. This new method of hot top heating makes it possible to increase the yield of good metal, with ingots of 800 kg, by 2.0 to 2.5%. For a further increase in the yield of good metal, efforts are being made to determine the best shape of hot top and to select the best insulating material for lining the hot top. In addition, the effect of briquetting the new thermal mixture is being investigated.

The use of intensified heating of feeder heads makes it possible to reduce the weight of hot tops and the overall ingot weight. With the object of a more complete utilization of rolling mill capacity, reheating and lifting facilities, it is essential to increase the weight of the effective part of the ingot by reducing the weight of the hot top portion. By thus redistributing the metal, it is possible to improve ingot shape, to increase productivity and the yield in the roughing mill.

The central plant laboratories, together with the USSR Academy of Sciences Institute of Metallurgy, is investigating the possibilities of raising the productivity of open hearth furnaces in connection with the production of low carbon steel of the Armco type for electrical engineering purposes. Tests show that when rimming steel is vacuum treated, its carbon content is markedly reduced and this makes it possible to tap at 0.08 to 0.10% carbon and subsequently to reach a carbon content in the ladle of 0.025% with vacuum treatment. Tap-to-tap time and furnace wear are thereby reduced.

The heating of feeder heads for shaped castings can be effected by burning 75% FeSi in a stream of oxygen or by using the new exothermic mixtures. The first method is obviously the best for castings of over 5 tons weight while the exothermic mixtures based on FeSi, SiCa and saltpeter are more widely used for castings weighing up to 5 tons. Intensive heating of feeder heads for shaped castings makes it possible to reduce metal consumption by 10 to 15% and to obtain a sounder casting.

Plans for laboratory research include the determination of metal pressure on the rolls in section mills so as to establish optimum conditions for heating and hot working of steels of various grades. This work is directed towards increasing the amount of possible reduction in rolling and raising the productivity of the 450 train.

The hot drawing of Kh18, 9kHS, 60S2, R18 and some other grades of steel gives rise to a substantial increase in mill productivity and gets rid of cracks and tears. At present, the technology of drawing is being developed and careful selection is being made of a method of heating (gas or electric), of the optimum drawing speed and of the most efficient lubrication.

In order to obtain patented wire with only slightly oxidized surface, the passages of the patenting furnace were made of runner brick, all the joints being carefully smeared with a highly refractory mass. The bricks were laid on a layer of ground chrome-magnesite.

From the furnace to the patenting bath, the wire passed through a special hermetic intermediate trough. The bath was filled with molten pure caustic soda (NaOH).

With patenting, a wire is obtained with a scarcely oxidized surface and five to eight minutes is sufficient for pickling. However, after a short period of pickling, the surface of the wire becomes so smooth that the lubricant is not absorbed in the groove of the draw plate and the drawing process is greatly complicated. At drawing speeds of over 250 meters per minute, the draw plates are severely worn.

The plant maintains a constant struggle against defects in ball-bearing grade steel as regards decarburization and, unfortunately, it has not yet been possible to obtain satisfactory results. At the same time, our customers are demanding new and higher standards in the quality of ball-bearing steel. A study of the experience of the Red October, Serov and Zlatoust Plants in the production of ball-bearing steels will lead to a satisfactory solution of this problem.

Mechanization and automation of the hardening of thin stainless steel sheets is possible only in contemporary furnaces with a mechanized hearth. In stainless steel hardening furnaces with a roller hearth, the life of the rollers is quite short. Unfortunately, we know of no alloys which would operate for a long period under load at 1100° to 1150°C. Consequently, it is essential to find a material for the rollers and to develop a design of roller which would ensure reliable operation of the hearth. At the same time, it is essential to check the possibility of lowering the operational temperature of the furnace to ease the conditions under which the rollers operate.

Apart from the thematic work, the central plant laboratory is also undertaking work on an operative plan involving questions which have become prominent among shop operatives and urgently demand a solution. This plan, confirmed by the Chief Engineer of the plant, included eleven items. Among these are: 1) perfection of the technology of casting stainless and heat-resisting grades of steel; 2) development and introduction of technological methods of reducing cracking in manganese castings; 3) development and introduction of new mold and core mixes, paints and coatings with the object of reducing rejects in shaped castings on account of scabs, impurities and sand pick-up; 4) developing measures to combat blowholes on rimming steel sheet; 5) a study of the causes of increasing tensile strength along cable wire and the development of means to remove such causes; 6) investigation and removal of the causes of cracking in 60S2 and KhVG steels during drawing.

AN EXTENSIVE MINING AND METALLURGICAL REGION

A SCIENTIFIC CONFERENCE ON THE PROBLEMS OF THE TURGAI REGIONAL ECONOMIC COMPLEX

M. Darishev

(Kazakh SSR Academy of Sciences)

Between the spurs of the southern Urals and the Kazakh uplands, there extends the vast region of the Turgai lowlands. During the last ten years, enormous reserves of iron ore have been discovered in this territory. The magnetite ore reserves of the new Kustanai basin exceed those of Lake Superior in the USA where up to 80% of all the iron ore consumed by the American iron and steel industry is mined. Iron ore reserves in the Kustanai basin exceed ten billion tons while Western Europe's largest iron ore reserves in Lorraine and Sweden constitute less than six billion tons (two-thirds of the pig iron output of all the capitalist countries of Europe are based on these iron ore deposits).

In addition to iron ore, unusually large reserves of bauxite, coal, refractory clays and building materials have been discovered in the depths of the Turgai depression.

The presence of such a complex of mineral and raw materials wealth opens up magnificent prospects for the development of a mining and metallurgical industry in the Kustanai region.

From the 20th to the 24th of May, 1957, the USSR Academy of Sciences, the Kazakh SSR Academy of Sciences and the Ministry for Geology and the Preservation of Kazakhstan's Mineral Resources organized a joint scientific conference on the problems of the Turgai regional-economic complex. Four-hundred thirty scientific workers and workers in the national economy from Moscow, Alma-Ata, Leningrad, Sverdlovsk, Kharkov, Chelyabinsk, Magnitogorsk and other cities took part.

In the report on "The Productive Forces of the Kistanai Region and the Problems of Their National Economic Utilization," the Secretary of the Kustanai Regional Committee of the Kazakhstan Communist Party, I. P. Khramkov stated that there were sufficient water resources in the region for the integrated development of the national economy. The waters of the Tobol and Ishim Rivers can satisfy the requirements not only of a large iron and steel plant but also of other highly important undertakings of the region. This will enable the metallurgical plants of the mighty TETs to be located directly on the ore and coal fields. Nevertheless, when undertakings are being planned, it is necessary to provide for water recirculation and to choose schemes requiring very low water consumption.

The speaker gave a detailed account of the progress of development work relating to the utilization of mineral resources. At Sokolovsko-Sarbai, they are presently building the largest minerals concentration combine in Europe with an ultimate annual productive capacity of 20,000,000 to 22,000,000 tons of crude ore. In the current year, the combine will produce 265,000 tons of ore and, in the coming year, ore output will exceed one million tons.

I. P. Khramkov pointed out that it was essential to organize a Kazakh SSR Academy of Sciences scientific research institute in the Kustanai region with branches of such planning organizations as the State Institutes for Mineral Planning, and for the Planning of Iron and Steel Plants and for the Planning of Mines (Giprorud, Gipromez and Giproshakht), etc.

The report on "Natural and Economic Resources of the Kustanai Region as a Basis for Specializing and Coordinating Its Economy" was made by the Chairman of the USSR Academy of Sciences Council for the Study of Productive Forces, Academician V. S. Nemchinov.

He noted the advantages of using Lissakov ores as compared with Ayat ores and he raised the question of building a metallurgical plant to produce 3,000,000 to 3,500,000 tons of pig iron a year. Capital expenditure per ton of ore prepared at the Lissakov ore fields was two-thirds that of ore prepared at the Ayat field while the cost of a ton of pig iron produced from Lissakov ore is 10% less than Ayat iron. In addition to this, the smelting of 3,000,000 to 3,500,000 tons of pig iron makes it possible to obtain 560,000 to 630,000 tons of valuable mineral fertilizers (basic converter slags) essential for the virgin soils of Kazakhstan. The speaker supported, from an economic point of view, the claim that the basic converter process was the most expedient for producing steel from Lissakov iron ores. Capital investment per ton of steel produced by the basic converter process is, on the average, two-thirds that of open hearth steel, the net cost of converter steel being 8 to 10% lower while labor requirements are 25 to 30% less than for open hearth production.

The head of the Gosplan (State Planning) Department of the Allocation of Productive Forces, S. P. Tokarev, in his report "Basic Trends in the Development of the Most Important Branches of the National Economy of the Kustanai Region for 1960 to 1975," informed the Conference that planning and research work in connection with the powerful mineral concentration combine based on the Lissakov phosphoric ore deposits will be completed during the sixth Five-Year Plan. In this same Five-Year Plan, work on the Kushmuruk brown coal deposits will be commenced and the first pit of 3,000,000 tons capacity will be built. The total reserves of the Ubagan brown coal basin will many times exceed those of the entire Urals coal deposits. Coal production in this basis will reach 40,000,000 tons a year in the near future.

The Turgai bauxite deposits are also being explored. These deposits may likewise be of major industrial importance to the country. The mines which are being developed will serve as a base for the largest aluminum plant in the world at Pavlodar. A railroad is presently being built to run from the station at Yessil to these mines.

In the current Five-Year Plan, a new center of the asbestos industry is being developed, based on the rich asbestos reserves of the Dzhetygarin area. The Kustanai region may become the largest supplier of high grade refractory products.

Outlining the basic trends in the development of the most important branches of the Kustanai region's national economy during the next two or three Five-Year Plans, the speaker dwelt on development in ferrous metallurgy. Today, Kazakhstan occupies first place in the USSR as regards iron ore reserves, surpassing the Ukraine and the Urals.

The speaker especially emphasized the utmost importance of utilizing the rich magnetite ores of the Kustanai basin to relieve the shortage of blast furnace and open hearth ore at the existing plants of the southern Urals. As time goes on and the Magnitogorsk reserves and parts of the other Urals iron ore deposits are depleted, the demand for Kustanai magnetite ores will increase and these deposits will become the main base for the southern Urals iron steel industry, which, when fully developed, will require an average of 20,000,000 tons a year of concentrated iron ore.

The mining of phosphoric ores in the Lissakov and Ayat regions might attain several million tons a year from each. Mining these ores on such a scale would make it possible to support a number of heavy iron and steel plants.

Lenin Prize Winner S. D. Batishchev-Tarassov, head of the thematic group of the Urals Geological Administration, reported at the Conference, on the mineral resources of the Great Turgai and on the problems of future geological, geophysical, prospecting and exploratory work. He stated that the explored reserves of iron ore and brown coal in the Kustanai basin exceed by far the reserves of the Urals which have been under examination during the past 250 years and more. Rough estimates show that the possibilities of exploiting the region's known ore fields will amount to 120,000,000 to 150,000,000 tons a year and consequently the development of an iron and steel industry is here no longer limited by the supply of raw materials. Reserves of coal for power in this area presently amount to 40 to 50 billion tons.

More than 150 persons took part in the discussion of the report.

The scientific session adopted a carefully calculated resolution regarding ways and means of utilizing the natural resources of the Kustanai region and recommended that the USSR and the Kazakh SSR Academies of Sciences and the Kustanai Council of National Economy, together with the interested scientific research and planning institutes should drew up and develop scientifically a plan to rationalize the development of the national wealth of the Kustanai region after they have finally worked out, in the first six months of 1958, their plan for the integrated development of the most important branches of industry before 1975.

The USSR Academy of Sciences Council for the Study of Productive Forces has been commissioned to work out, by 1959, a comparative technical and economic evaluation of basic trends in the rational utilization of the natural resources of the Kustanai administrative-economic region and also to study interregional communications between the Kustanai economic region and other economic regions of the country.

The Conference recommended that the Kazakh SSR Academy of Sciences, the Kazakh SSR Gosplan and the Kustanai Council of National Economy, together with the USSR Academy of Sciences, should draw up, by the end of 1957, a schedule of the most important measures to be taken for the development of the Kustanai region's productive forces and should give the Council of Ministers of the Kazakh SSR and the government of the USSR an idea of how these measures should be carried out.

INCREASING THE SMELTING RATE OF BLAST FURNACES

M. Ya. Ostroukhov

(USSR Academy of Sciences, Institute of Metallurgy)

The question of increasing the intensity of blast furnace smelting is very complex. It is possible to push the furnace by increasing the blast volume. Beyond a certain limit, however, the furnace will not "take blast." The correct descent of the burden and distribution of the gas streams in the furnace are impeded, "channeling" occurs where the gases take a preferential direction and there is an increase in flue dust. Burden descent is periodically retarded, "hanging" takes place and the burden materials sometimes "slip," unsmelted charge reaches the hearth and smooth operation of the furnace is disturbed. In some cases forceful measures are required to settle the burden. After such unsuccessful attempts to push the furnace, much time and labor are lost in an effort to right the furnace. Meantime, productivity falls and coke consumption is increased.

Thus, the possibility of increasing the rate of smelting by forcing the blast is limited for aerodynamic reasons. Increasing the amount of coke burned per unit of time increases the volume of gases per m^2 of cross sectional area of the stack, the speed of the gases is raised, the upthrust of the gases is increased as a result of which the burden might well cease to descend.

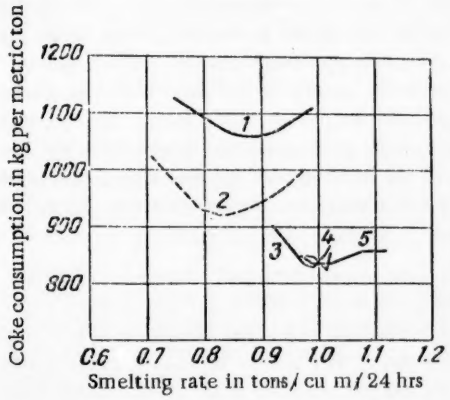
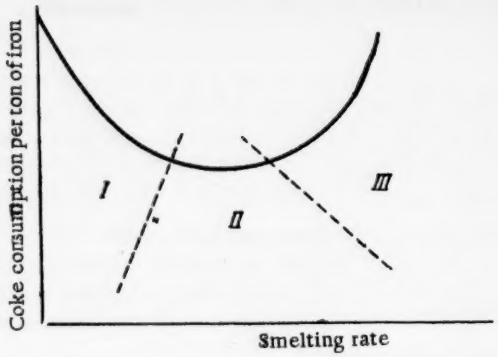


Fig. 1. Relationship between rate of smelting and coke consumption per ton of iron. 1) Azovstal No. 3 furnace 1946-1949; 2) Zaporozhstal No. 3 furnace 1948-1950; 3) Magnitogorsk No. 1 furnace 1948-1950; 4) Magnitogorsk No. 6 furnace 1948-1950; 5) Magnitogorsk No. 2 furnace 1948-1950.

It should also not be forgotten that long before the smooth operating conditions are disturbed by aerodynamic factors arising from the increased rate of smelting, coke consumption per ton of iron begins to increase. Figure 1 indicates the relationship between coke consumption and the rate of smelting for various blast furnaces. At a certain rate of smelting, coke consumption is at a minimum. In the case of the Azovstal and Zaporozhstal furnaces, operating on unprepared Krivoi Rog ores, this rate is 0.8 to 0.9 tons per m^3 per 24 hours while, at Magnitogorsk Iron and Steel Combine, where the furnaces work on well prepared ores, the rate of smelting at which coke consumption is at a minimum is 1.0 tons per m^3 per 24 hours.

The "smelting rate-coke consumption" curve can be divided into three zones (Fig. 2). Zone I corresponds to an incorrect distribution of gases in the stock column caused by insufficient upthrust of the gases; with such a distribution of gases the ore is badly smelted and reaches the hearth in an insufficiently reduced state, which increases coke consumption. Zone II corresponds to minimum coke consumption and represents the optimum conditions for good utilization of thermal and chemical energy of the gases. Zone III corresponds to the type of gas distribution which causes "channeling" in the stock column; the gases, moving mainly through "channels" are not able to reduce the ore adequately, their chemical energy is not completely utilized and coke consumption rises.



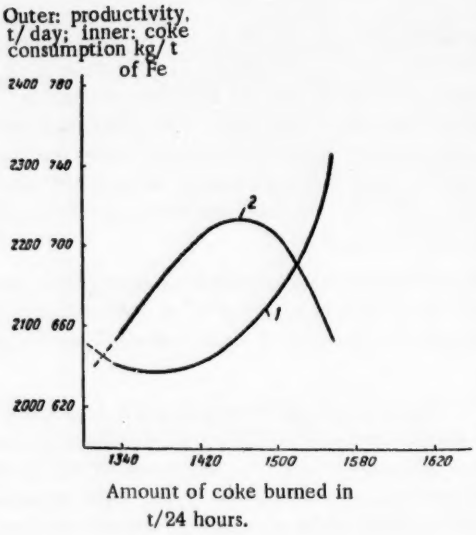


Fig. 2. Relationship between rate of smelting and coke consumption: top) theoretical; bottom) on one of the Magnitogorsk furnaces: 1) coke consumption, 2) furnace productivity.

Soviet blast furnace operators endeavor to work on the boundary of Zones II and III, but sometimes, in order to step up furnace productivity, they operate in Zone III in spite of rising coke consumption; with a further increase in the rate of smelting, coke consumption continues to rise and furnace productivity falls (Fig. 2).

The possibility of increasing the rate of smelting depends on the gas permeability of the burden. This is evident from the diagram which shows the relationship between the rate of smelting and the amount of −5 mm fines in the ore. When the −5 mm fraction is reduced by 7.8%, the rate of smelting is raised by 10.4%. Consequently, it is essential to use well-prepared lumpy charge which does not contain material smaller than 5 mm.

The development of blast furnace production in the USSR proceeds in two directions − an increase in the rate of smelting and a reduction in coke consumption. In both cases blast furnace productivity is increased while in the second case there is also a reduction in the cost of iron (coke is the most expensive material in the smelting process). Frequently, blast furnace productivity can be increased by both methods simultaneously.

A reduction in coke consumption is facilitated by higher blast pressure and the use of self-fluxing sinter. With lower coke consumption, however, the permeability of the burden deteriorates, since the relative proportion of coke in the burden is reduced, while the ore (or sinter), as the finer material, exhibits greater resistance to the passage of the gases than does the coke. The higher the ore charge, the greater is the hydraulic resistance of the stock column. This explains the reduction of the smelting rate in some blast furnaces which formerly had a high smelting rate (1.1 ton per m^3 per 24 hours).

In some plants which had achieved a very low coke consumption (600-650 kg per ton of iron), a further increase in the rate of driving presented a very complex problem. Only a very slight additional reduction in coke consumption can be attained as the figure of 600 kg of coke per ton of iron is close to what is theoretically possible. Consequently, in order to increase the rate of smelting, the gas permeability of the stock column must be increased mainly by increasing the pressure of the gases in the furnace chamber. In this case, the speed of the gases in the stock column is substantially reduced and a greater volume of gases can pass through the furnace, thus improving the rate of smelting. When the gas pressure is increased, possibility of "channeling" is reduced.

High top pressure is widely used in Russian blast furnaces. In many furnaces the top pressure is 0.6 to 0.7 atmos, and in some furnaces it is 1.0 to 1.2 atmos. This makes possible a marked increase in the amount of pig iron produced and has the effect of lowering coke consumption to some extent. It should be pointed out that when putting furnaces on high top pressure a number of constructional difficulties make it essential to have the top charging gear hermetically sealed and the working parts strengthened.

Some increase in furnace output can be attained by moistening the blast. Blast humidification is used at all Russian blast furnace plants. The moisture content is normally 20 to 25 g per m^3 at N.T.P., a further increase in blast humidification being limited by the possible blast temperature.

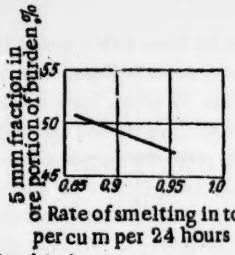


Fig. 3. Relationship between amount of fines in the ore and the rate of smelting.

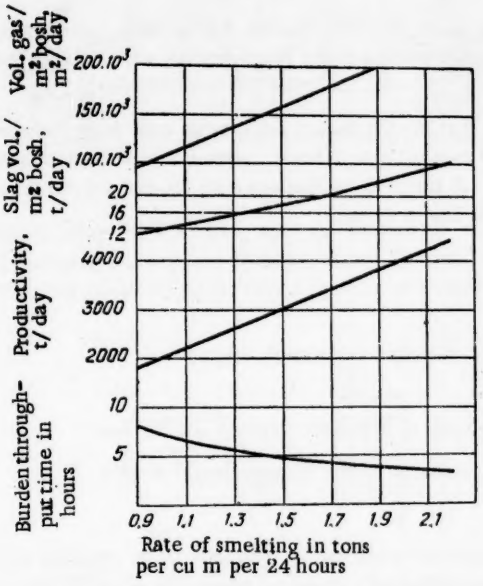


Fig. 4. Calculated relationship between burden throughput time, furnace productivity, volume of gases and slag per m^2 of bosh per 24 hours and the rate of smelting (for Magnitogorsk conditions).

Recently, yet another means of increasing the smelting rate was examined – enrichment of the blast with oxygen. On No. 4 furnace at Nizhne Tagil, trial casts were successfully made with 22 to 24% oxygen in the blast. Furnace productivity was increased by 7% but there was no change in coke consumption. The furnace worked smoothly in spite of the fact that blast temperature was raised by 40°C; the moisture content of the blast was not increased above normal (20 g per m^3 at N.T.P.). The trial casts showed that the oxygen-enriched blast (enriched up to 23 to 24%) had a very favorable effect on the production of pig iron for steelmaking purposes. The wide use of oxygen-enriched blast is still limited because oxygen is so expensive.

Burden permeability can be increased by block charging of the different size fractions of the ore portion of the burden. The advantage of this was shown by G. F. Mikhalevich, I. A. Nekrassov and a number of other Soviet specialists as early as 1928.

The 10 to 40 mm sinter fractions, for instance, must be charged into the blast furnace separately from the 40 to 60 mm fraction. Lumps of sinter greater than 60 mm must be crushed, so it is essential that sinter plants be equipped with crushers and screening equipment.

The block charging of coke is also of great importance. The coke must not be less than 40 mm in size. Experience of the operation of large blast furnaces at the Dzerzhinsky Plant which were operating on coke larger than 40 mm size shows that the rate of smelting in this case can be increased up to 1.15 to 1.20 tons per m^3 per 24 hours. Coke smaller than 40 mm must be reserved for furnaces of small volume.

Recently in the Soviet Union and abroad much interest has been aroused by the use of granules of very fine ore concentrates in the blast furnace burden. Such granules can be produced by high productivity units (rotary tables). In order to strengthen the granules, they are roasted on sinter belts. This enables rounded granules of uniform size to be obtained. A burden consisting of such granules must exhibit less hydraulic resistance so that the gases will move between the granules in a more regulated manner and local resistances, caused by expansion and constriction of the channels and forming the major part of the hydraulic resistance when the gases move in a medium of loose, free-flowing materials, must be substantially reduced. In this connection it is essential that such granules should be equal in chemical composition to the self-fluxing sinter, i. e., should contain the necessary amount of fluxing additions.

All these measures are associated with a substantial reduction in the hydraulic resistance of the stock column. The rate of smelting can be greatly increased by them. The only doubtful factor is connected with ore reducibility when the smelting rate is further increased. It is calculated that the optimum degree of indirect reduction of ore (and consequently coke consumption) depends on burden throughput time. In modern blast furnaces this time is normally 7 to 8 hours.

Figure 4 indicates the relationship between the volume of gases and slags per m^2 of cross sectional area of the bosh, the burden throughput time and furnace productivity and the rate of smelting under Magnitogorsk con-

ditions. Coke consumption is equivalent to 600 kg per ton of iron. In making these calculations it was assumed that an increase in the smelting rate is assured by improved permeability and reducibility of the stock. The calculation shows that when the smelting rate is increased to 1.5 tons per m^3 per 24 hours, burden throughput time is reduced to 4.75 hours and when the smelting rate is increased to 2.0 tons per m^3, burden throughput time is reduced to 3.56 hours. Can it be calculated that, with such a high smelting rate, the degree of indirect reduction will be sufficient to reduce ore during this period without increasing coke consumption? To answer this question, we must remember that when operating on charcoal, burden throughput time in Urals blast furnaces was reduced to 3.5 to 4.5 hours. These furnaces were working on highly reducible ores (limonites). We may cite the example of No. 1 blast furnace of the Serov Plant in the Northern Urals operating on less reducible ore with a burden throughput time of 3.5 hours and a low charcoal consumption – 660 kg per ton of iron. Burden throughput time in the Serov blast furnaces operating on coke and at a high smelting rate is 6 hours. These furnaces, however, have a high coke consumption (850 to 900 kg per ton).

The burden throughput time can be reduced by using an easily reducible burden, for instance, self-fluxing sinter with a high basicity ($CaO : SiO_2 = 1.4$-1.5) such as is used at present in the Magnitogorsk and Kuznetsk iron and steel combines.

On the basis of what has been said it may be concluded that burden throughput time in coke blast furnaces operating at a high smelting rate can be substantially reduced to as little as 5 hours. With a 5-hour burden throughput time at Magnitogorsk, the smelting rate can be increased 1.5 times in comparison with the present one (see Fig. 4) while the blast furnace coefficient can be reduced to as low as 0.433.

DUST-REMOVING EQUIPMENT FOR SINTERING PLANTS

Cand. Tech. Sci. A. V. Sheleketin (Krivorog Institute of Industrial Hygiene and Disease)

and Engineer N. S. Karpushinsky (Sintering Department of the "Zaporozhstal" Works)

The raw materials for the sintering plant of the "Zaporozhstal" works are sprayed with water when the external temperature is above 0°C and there is no atmospheric precipitation. When the moisture content of the lime entering the plant is 0.3-0.5%, movement and crushing of the lime results in a dust content of the air of 250-500 mg/m^3. The dust cannot be removed by exhaust fans, and therefore the lime is sprayed in the bunkers and during unloading to raise the moisture content to 2.0-2.5%. When this is done, the dust content of the air drops rapidly to an average figure of 15 mg/m^3.

Two type U-1 sprayers are mounted in each bunker for uncrushed lime. The sprayer jets are directed toward the middle of the bunker. The material is moistened in layers as it enters the bunker.

A new method of spraying the lime is being tried at the present time. Before crushing and pulverizing, the lime charged into the bunkers is sprinkled evenly by means of two sprayers mounted in the dumping car hoppers. When the conveyor stops, the supply of water to the sprayers is also stopped automatically.

The charging openings of the lime bunkers are equipped with flaps (Fig. 1). This has made the bunkers more airtight with the result that less dust gets into the building.

As the dumping car moves along, an opening device mounted on the hopper lifts the flaps. When the car has passed, the flaps close under their own weight.

Before being crushed, coke breeze is sprayed to 8% moisture while it is being discharged from the bunkers to the conveyors. Ore has to be sprayed to a moisture content of 6-8% and blast-furnace dust to 6%. The manganese ore has a moisture content of 12-18% on arrival and therefore does not have to be sprayed.

The sprayers for wetting the materials are mounted in positions convenient for inspection. If the pressure fluctuations in the water mains are considerable, it is advisable to provide pumps and equalizing tanks.

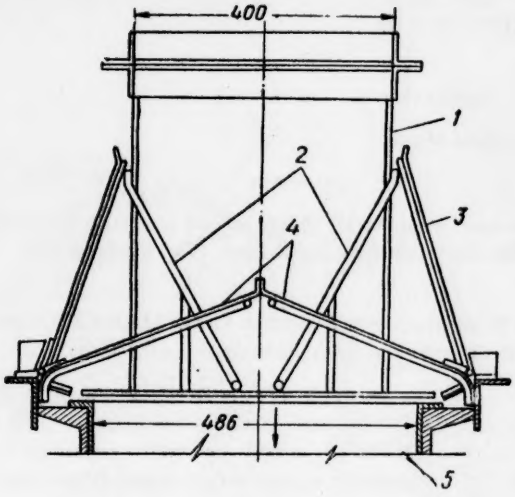


Fig. 1. Flaps on the filling opening of bunkers. 1) Dumping car hopper; 2) flap opener; 3) open flaps; 4) closed flaps; 5) filling opening of bunker.

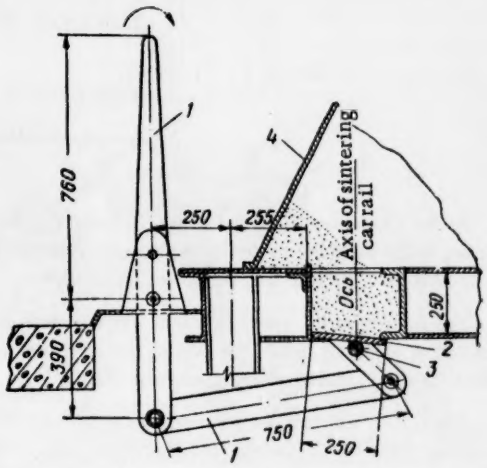


Fig. 2. Dust-removing equipment for sintering machine. 1) Lever; 2) 250 x 1850 mm gate; 3) gate spindle; 4) sintering machine casing.

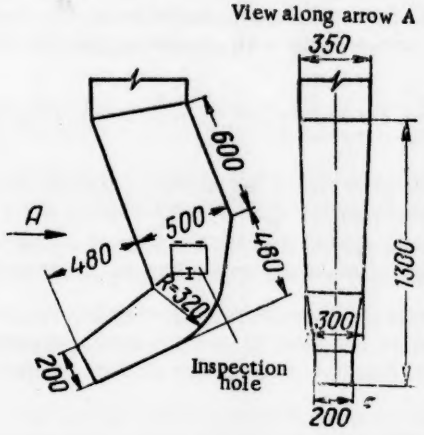


Fig. 3. Nozzle on spreading hopper.

For preventing the wet material from sticking to surfaces, electric vibrators are provided in the bunkers and some dumping cars.

The dumping cars of conveyors for filling the charge bunkers have been redesigned for one-sided dumping, so as to reduce the area of the opening into the bunkers.

The sintering machines are enclosed in airtight suction casings so that the natural ventilation of the sintering plant can be utilized more effectively and the amount of dust sent into the atmosphere reduced. Working difficulties connected with the use of enclosed casings for the sintering machines are currently being eliminated. For improving the suction in the casing of a working section of the sintering machine, the gaps between the working section and the idle section were formerly covered by iron plates. Dust accumulated on these plates and impeded the normal movement of the pallet rollers on the rails. To remove the dust from under the casings, the latter had to be dismantled and the dust removed by manual labor. The dust is now removed from the casings through airtight gates or valves (Fig. 2). The gate is swiveled by means of a lever and the dust dumped into bunkers. The provision of gates makes it unnecessary to dismantle the casing for removal of dust.

Nozzles (Fig. 3) have been mounted on hoppers, through which the material flows smoothly and slowly to the middle of the belt. Grate bars, pieces of metal, and other accidental objects are retained in the nozzles and can be removed through a special inspection hole. Before these nozzles were provided, the dust content of the air at the discharge points of the spreading hoppers was 50-150 mg/m^3; it has now been reduced to 15-20 mg/m^3. The dust content in these sections can be reduced still further by providing the nozzles with suction hoods.

DEFECTS IN THE PLAN FOR SUPPLYING SINTER TO BLAST-FURNACE BUNKERS BY CONVEYORS

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Cherepovetsk Metallurgical Works

At the Cherepovetsk Metallurgical Works, for the first time in the Soviet Union, all raw materials including sinter are being supplied to the blast-furnace bunkers by rubber belt conveyors (see figure). The widths of the belts are 800 to 1000 mm and the speed is 1.6 m/sec.

The design for the sintering plant was the work of the Scientific Research Institute for the Mechanical Concentration of Minerals, while the rest of the conveyor project was executed by the Leningrad branch of the State Institute for the Planning of Metallurgical Plants.

The sinter, which has a temperature of 400-600°C, passes to the pan coolers, which have a diameter of 18 m, for cooling to 60-70°C, since at a higher temperature than this the rubber belt is rapidly destroyed. According to the project, one pan cooler was to serve two sintering strands. In actual practice, however, it cannot ensure adequate cooling of the sinter from even one strand. The sinter has to be sprayed intensively with water, which results in an increase in the fines (especially in highly basic sinter). An experimental pan cooler with a diameter of 8.5 m and forced air cooling is currently being erected. After it has been started up, the 18 m diameter coolers will be re-equipped for forced cooling.

The construction of a second 18 m diameter pan cooler and the 8.5 m diameter cooler, which were not included in the project, led to some complication in the conveyor scheme for this section and an increase in the number of transfer operations. For transferring the sinter from the screens to the auxiliary coolers, plate feeders are used, which are extremely difficult of access.

Before entering the blast-furnace bunkers, the sinter undergoes 5-7 transfers, which helps in increasing the amount of fines and dust.

To minimize belt wear and prevent it from coming off the guide rollers, the projection onto the belt of the vector of the velocity of movement of the material in the hopper should agree with the velocity of the belt in direction and magnitude. To soften the impact of the material against the belt, the angle of inclination of the bottom of the hopper is made 50-10° larger than the angle of friction of the material against the bottom.

Despite these circumstances, the transfer points of the conveyor plant have been designed so that the projection of the velocity of the arriving material is much higher than the belt velocity, and at a number of points is directed at right angles to it. The angle of inclination of the end hoppers is much greater than the permissible angle. All this results in rapid wear of the belts.

The belts of conveyors 47 and 48 leading from the coolers to the sinter-classifying screens rapidly wear, due to the action of water and the high sinter temperature. No provision has been made for spare conveyors in this section.

Conveyors 13 and 14 carrying sinter from the sinter screening plant to transfer point 10 do not ensure the required productivity.

The narrowest point in the conveyor system is transfer point 10, which is the end or starting point for 9 conveyors.

When being transferred from conveyors 13 and 14 to conveyors 18 and 18a, the sinter falls from a height of up to 7 m, and the direction of its fall is always varying.

At this point, the guide hoppers have been designed with a small cross section (540 x 400 mm), the sheet metal being 6 mm thick. They are often blocked and wear out rapidly. These hoppers are difficult to repair owing to overcrowding and dust. The reversing valves for distributing the material among the conveyors also do not work properly. Consequently the cross section of the guide hoppers has now been increased to 600 x 700 mm

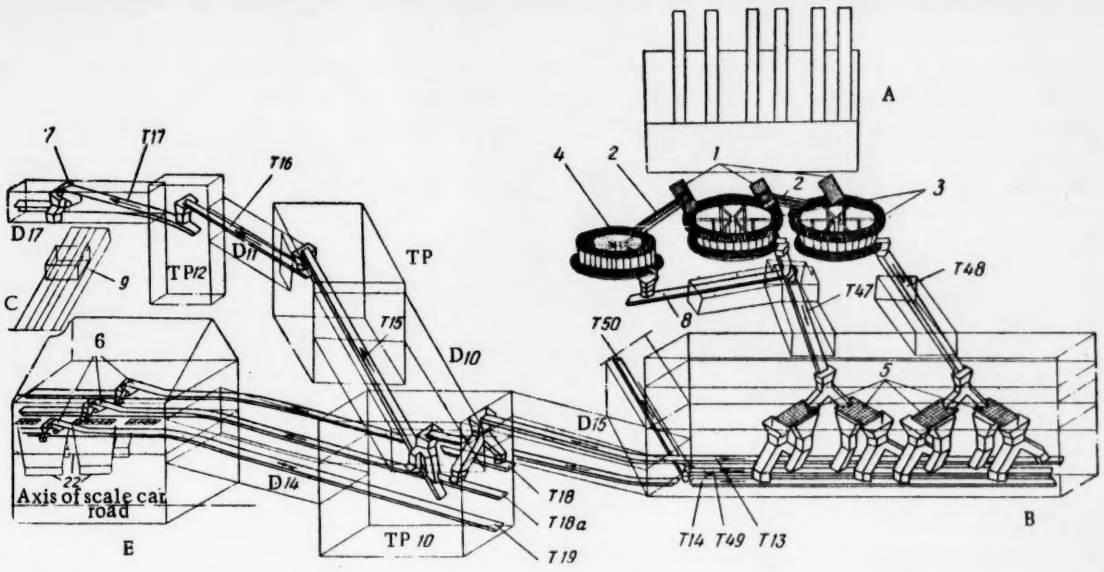

Diagram of sinter supply to blast-furnace bunkers. A) Sintering plant; B) sinter screening unit; C) stock yard; D) conveyor galleries; E) bunker gantry; TP) transfer points; T) conveyors; 1) bar screens; 2) plate feeders; 3) coolers; 4) 8.5 m diameter cooler; 5) vibrating screens; 6) bunker gantry dumping cars; 7) stock yard dumping car; 8) auxiliary conveyor; 9) grab crane.

and the thickness of the sheet metal to 10 mm. The hoppers are armored at the point of maximum wear. The valves are being replaced by sector gates actuated by manually operated winches.

In the closed building of the bunker gantry, the sinter, coke and lime from conveyors 18, 18a and 19 are transferred to the bunkers by three dumping cars.

The apertures of the bunker inlet gratings are of small cross section, the gratings are often clogged and out of action. Safety regulations prohibit any increase in the size of the grating apertures.

Conveyors 18, 18a and 19 are situated very close together, which makes repair and servicing difficult. The plan contains no provision for the removal of material left on the belt at the end of the first gantry line. The dumping cars made at the Belokholunitsk works are small and slow-moving.

The scraper cleaners provided for belt cleaning on the end driving drums are very unsatisfactory in operation.

Considerable defects in the projected ventilation system should be mentioned. The repeated transfer of sinter and the absence of covers on the conveyor belts result in considerable dustiness throughout the entire conveyor system. The natural and artificial ventilating devices do not help much in removing the dust. The working conditions in the buildings of transfer point 10 and the bunker gantry are particularly onerous. The bunker inlet gratings are currently being covered in and fan ventilation is being provided.

The plan of the conveyor system has paid very little attention to safety problems. The driving, tensioning and deflecting drums are unguarded, and guards have not been provided for the drive and hoppers of the dumping cars. The various ladders, gantries and repair platforms, necessary for working the plant, have not been provided in the project.

To rectify the shortcomings of the projected conveyor system, the number of transfers should be reduced, spring-mounted roller supports should be provided at the points where sinter is loaded-off onto the belt, and revolving brush cleaners should be provided for the driving drums and for the lower branch of the belt. Points of maximum wear of hoppers should be lined with manganese steel.

A reliable automatic system should be devised for the remote control of the entire conveyor system.

Despite all the shortcomings of the project executed by the Scientific Research Institute for the Mechanical Concentration of Minerals and the Leningrad branch of the State Institute for the Planning of Metallurgical Plants, it may be stated with conviction that the supply of sinter to blast-furnace bunkers by conveyors shows considerable promise. If materials are supplied by conveyor, there is no necessity for an elevated railroad or a considerable stock of railroad cars. Supply by conveyor permits an approach to be made to the automation of blast-furnace charging. In projecting new blast-furnace plants with conveyor supply, the above shortcomings should be borne in mind and rectified.

FUSED STONE SLABS – A WEAR-RESISTANT PROTECTIVE MATERIAL

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In the metallurgical and ore-mining industries, large quantities of material are transported: ore, coal, fluxes, etc. These materials are crushed, screened, concentrated and repeatedly moved on different conveyors, feeders, troughs, hoppers, etc.

Parts of the equipment and particularly the conveyor equipment are subjected to intense abrasive wear; to protect them from wear, linings of high manganese sheet steel or cast steel are used. The continuous operation of concentrating and sintering plants, coke ovens, refractory plants and blast-furnace plants depends largely upon the durability of these linings. The metallurgical industry uses thousands of tons of metal for protective linings; some of this metal is worn away and lost.

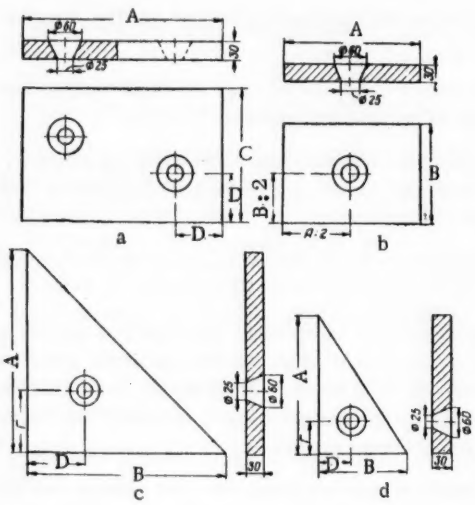

Fig. 1. Fused stone slabs. a) Nos. 1-4; b) Nos. 5-7; c) Nos.8-10; d) Nos. 11-12.

In many cases, the protective linings may be made of fused (cast) stone slabs. Such slabs are wear-resistant and considerable quantities of steel can be saved by their use.

The stone slabs are cast from basalt and diabase. These rocks differ little from each other in physical and mechanical properties; the difference in their chemical composition is not great and is of no account when they are used as protective materials; in what follows therefore, reference will be made only to basalt.

The fundamental properties of this material are as follows:

Specific gravity	2.9-3.1
Ultimate compressive strength	1800-2600 kg/cm^2
Hardness (Mohs scale)	8-9
Melting point	1450°C

Basalt resists the action of acids and alkalis.

Even before World War II, fused stone slabs made by the Moscow Stone Works were used extensively in the USSR for lining power station effluent conduits. The slabs are now used for lining cisterns, baths, vats and other apparatus for the storage of acids and alkalis. The slabs are also used in the by-product coke-oven industry.

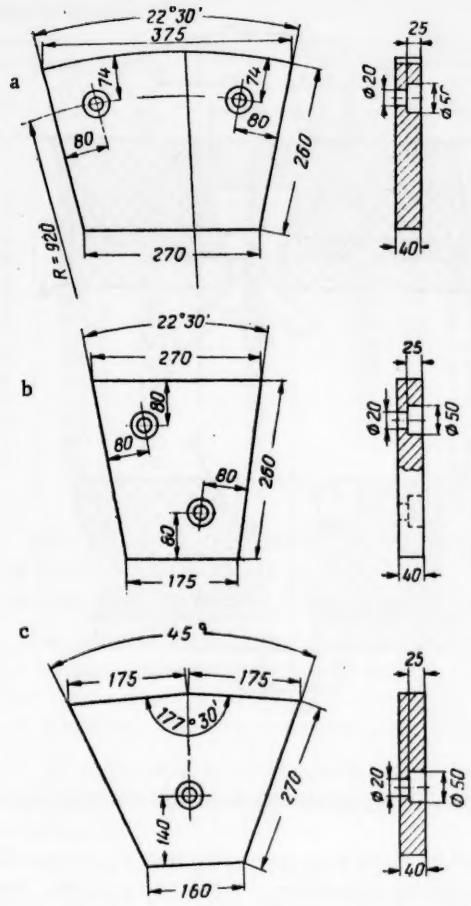

Fig. 2. Slabs for lining rotary table feeders: a) No. 13; b) No. 14; c) No. 15.

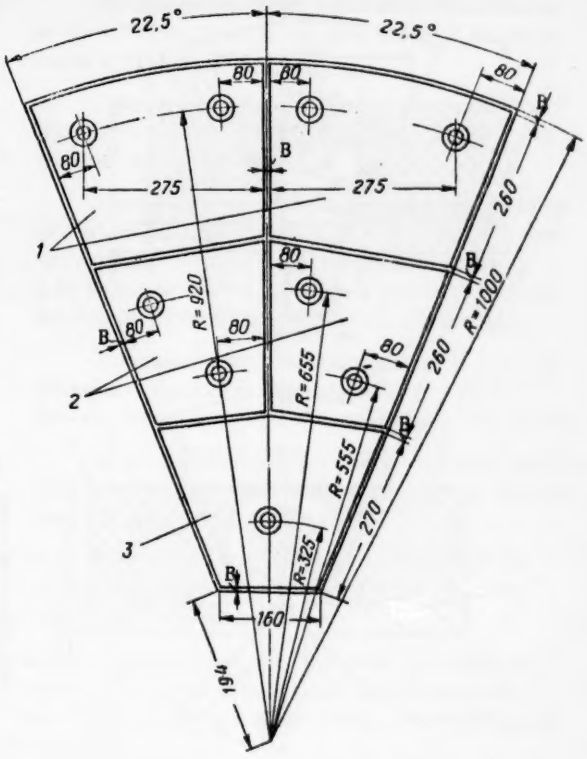

Fig. 3. Arrangement of basalt slabs on a 2 m diameter rotary table feeder. 1) No. 13; 2) No. 14; 3) No. 15.

The wear resistance of basalt slabs was first tried out in the iron and steel industry for coke chutes, then for mixing tables, crushed ore chutes and other sintering plant units.

In every case, the basalt slabs showed a high wear-resistance compared with carbon steel sheets, and even high-manganese cast steel G13L. At the Zaporozhe by-product coke-oven works, the basalt lining of the chute has been in use for more than eight years without replacement. A steel facing lasts 3-5 months in the same conditions.

At the Krivorog Southern Ore Beneficiation Combine, the steel-faced plates of the overflow troughs of the classifiers used to wear by a thickness of 8-10 mm in the course of a year, and the sand troughs in 3-4 months; no wear has been found in the same troughs after using basalt slabs for six months. The slabs are also standing up well at the sintering plants of the Kirov and Enakievsk metallurgical works.

At the sintering plant of the "Azovstal," however, the life of the slabs was approximately the same as that of steel plates. The reason for the poor durability of the basalt was the low quality of a small batch of slabs due to trouble in the fusing process at the cast stone works.

The Norilsk Metallurgical Combine has had considerable experience in the use of fused basalt slabs and has constructed special kilns for fusing and heat treatment of stone slabs. According to information from this Combine, the resistance to wear of the basalt slabs is 10 times that of a special armor steel, and 40 times that of steel tubes.

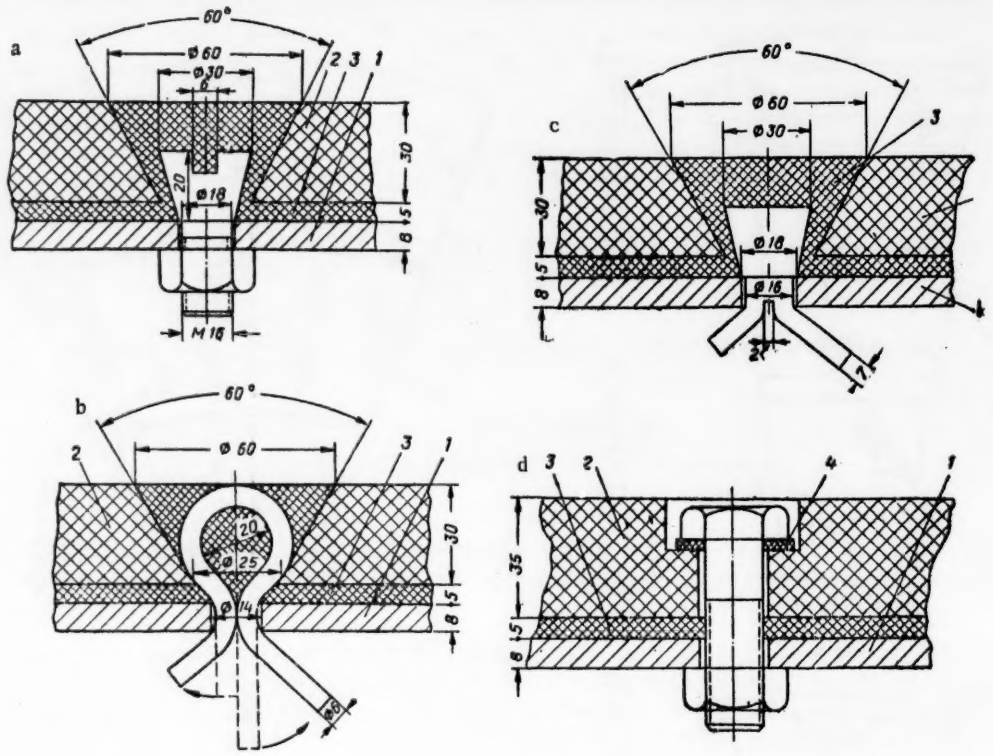

Fig. 4. Methods of fixing the slabs. 1) Metal plate; 2) slab; 3) cement underlay; 4) rubber washer.

In the Czechoslovak Republic, stone fusion has been used for many years for making slabs of different shapes for lining chutes, bunkers, effluent conduits at electric power stations and troughs at beneficiation works; fused stone pipes are manufactured for beneficiation works of the mining industry and for chemical works (centrifugal casting is used). According to references in the literature, fused basalt slabs began to be used in the USA in 1942 for lining coke chutes.

Experience acquired at works shows that fused basalt slabs are a good substitute for steel for facing surfaces subjected to wear. In addition to a high wear-resistance and other positive qualities, however, basalt slabs have their disadvantages; their chief one is low resistance to shocks and blows. They crack when dropped from a height of one meter onto a steel or concrete floor; they break when struck with an ordinary hand hammer. The deficiency in strength of basalt slabs to some extent limits the possibility of their use.

The limit shock loads of fused slabs has not yet been finally established, and therefore, works have to make their own tests to ascertain whether the slabs can be used in various units of equipment.

It is possible to recommend the use of basalt slabs for facing surfaces on which pieces of ore, lime and coke of a size of 50-60 mm (not exceeding 200 mm) are dropped from heights of up to 1 m.

The resistance of the slabs to splitting also depends upon whether they are correctly laid.

Iron and steel concerns are supplied with basalt castings only by the Moscow Cast Stone Works, which has a limited capacity and therefore inadequately satisfies the needs of our concerns.

The physical peculiarities of the basalt and the technical conditions of casting and its subsequent heat treatment at the Moscow Stone Casting Works are such that the latter cannot supply slabs of a size larger than 360 mm and a thickness greater than 40 mm.

Dimensions of Cast Basalt Slabs for Lining Surfaces Subjected to Abrasive Wear

Slab No.	Length A mm	Width B mm	Thickness C mm	Distance D from edge of slab to center of hole mm	Weight of slag kg
1	360	240	30	80	7.52
2	320	240	30	80	6.66
3	280	240	30	80	5.8
4	240	240	30	80	4.93
5	240	180	30	120	3.76
6	200	160	30	100	2.76
7	200	120	30	100	2.04
8	360	360	30	105	5.7
9	240	240	30	70	2.47
10	160	160	30	50	1.0
11	240	160	30	60	1.6
12	360	240	30	90	3.76
13	375	260	40	80	9.76
14	270	260	40	80	6.62
15	350	370	40	—	8.1

The dimensions of the basalt slabs manufactured by the works are given in the table and their shapes are shown in Figs. 1 and 2.

Figure 3 shows diagrammatically the method of laying slabs Nos. 13, 14 and 15 on a segment of a 2 m diameter disc feeder table.

The slabs are secured to metal parts of equipment (plates) on a cement mortar, with or without additional fixing means. Figure 4 shows the methods of fixing slabs by means of a conical headed bolt (a), wire loop (b), special pin with conical head (c) and bolt (d).

The underlay of cement mortar ensures close application of the slab to the metal over the entire surface and increases its resistance to splitting when struck.

At the Norilsk Combine, when lining wood constructions (troughs, pipes and the like), the slabs are fixed by means of nails with a conical head.

After laying and fixing the slabs, it is advisable to fill in the joints between them and the holes with the fixing means with a 1:3 cement mortar. The sand in the mortar may be replaced by finely crushed basalt or basalt flour. The slabs are best laid so that the joints are offset as in bricklaying.

The manufacture of basalt slabs is not difficult but requires special equipment. The basalt is melted in flame furnaces, resembling open-hearth furnaces in construction. The lumps of basalt are charged on shelves and the molten mass runs into the bath, from which it is run off into a ladle as it accumulates. The melting process is continuous. The furnace temperature is kept at about 1500°C.

The molten mass is ladled into open earth molds or metal molds and is at once transferred to the crystallization furnace. After remaining in the crystallization furnace, the molds are transferred to a tunnel furnace for slow cooling from 850°C to 100°C.

The heat treatment is necessary to impart a crystalline structure to the basalt slabs; if cooling is rapid, a vitreous structure is produced and the slabs lose strength.

A ton of the slabs shown in the table costs 1800 rubles. When comparing the costs of metal and basalt linings, it is necessary to take into account the difference in specific gravity of the materials and also their wear-resistance.

Up to the present the use of stone slabs in the metallurgical industry has not been as extensive as it deserves to be. The use of stone slabs for lining parts of equipment subject to wear will result in saving a large quantity of metal and increase the wear-resistance of plants.

STEEL MELTING PRODUCTION

WAYS OF INCREASING THE PRODUCTIVITY OF OPEN-HEARTH PLANTS*

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In 1955-1956, an investigation was made of the production organization in the open-hearth steel plants of the Magnitogorsk and Kuznetsk Combines and the "Zaporozhstal," "Azovstal," Kirov, Voroshilov and Dzerzhinsky works. The result of this investigation was a knowledge of the progressive experience of production organization in open-hearth plants with high-capacity furnaces.

In addition to plants enjoying high coefficients of utilization of open-hearth furnace capacity, a number of large open-hearth steel plants lag considerably behind those in the forefront. The difference in the productivity of 370-ton furnaces is particularly significant. Taking the quantity of steel melted annually in a 370-ton and a 185-ton furnace at the Kuznetsk Metallurgical Combine as 100%, the quantity melted in 370-ton furnaces at southern works is 25-30% less and in the 185-ton furnaces it is 10-15% less than at the Kuznetsk and Magnitogorsk Combines. An exception is provided by the "Zaporozhstal" works where there are only 185-ton furnaces using oxygen, the productivity of which is higher than the 185-ton furnaces at the Kuznetsk Metallurgical Combine.

The higher annual productivity of an open-hearth furnace at the Kuznetsk and Magnitogorsk Metallurgical Combines still does not characterize fully the level of production organization of these Combines compared with plants at southern works. To a considerable extent, this level is characterized by the degree of utilization of basic equipment and production areas, which is much lower in southern regions. The difference in the utilization of the capacity of open-hearth steel plants is determined to some extent by the differences in the quality of the raw materials and fuel – ore, hot metal, coke-oven gas. The chief causes for the inadequate utilization of open-hearth furnace capacity at works in the south still appear to be the considerable stoppages of furnaces for repair, and in particular, the long melting-down periods due to numerous disturbances in the established technical process, following serious defects in the production organization.

High productivity of open-hearth furnaces, especially in a large works, is only possible if the furnaces operate in a regular manner, the first criterion of which is regular tapping of the furnace in the course of a day. The regular working of an open-hearth furnace (as a thermal unit) during the course of a campaign, standardization of the technical process, properly conceived organization of production, operation of transport and equipment and exact planning – all these factors are fundamental conditions of regularity in tapping the furnace.

The regular working of an open-hearth furnace throughout a campaign depends largely upon the extent to which it is possible to preserve the original dimensions of the furnace, especially the dimensions of the ports, to protect the lining of the working space from irregular wear and to maintain effective operation of the slag pockets and checkers. These requirements are best met at the Kuznetsk Metallurgical Combine, where an exact program is drawn up for current maintenance of the furnaces and preventative hot repairs are carried out.

At the Kuznetsk Combine, at each heat, the dust is blown off the magnesite-chrome roofs, once a day the gas ports are inspected and repaired, and once a week the dust on the air bridges and outer lining of the port water-cooling elements is blown-off; the furnaces are stopped periodically for extensive hot repairs with fettling of water-cooling elements, repairs to ports, cleaning out the slag pockets and renewing the upper courses of the checkers. For smoothing out the thermal operation of the furnace, the thermal conditions of working are varied several times during a campaign.

* From a paper read at the All-Union Conference of Steel Melters.

As result of the steps enumerated in the foregoing, the life of the furnaces at the Kuznetsk Metallurgical Combine is longer and "aging" sets in later. Whereas in the 370-ton furnaces of the Kuznetsk Metallurgical Combine, the duration of the heats has increased by only 10-15% after 450-550 heats from the commencement of the campaign, in the furnaces of the Kirov, Dzerzhinsky and "Azovstal" works, such an increase in the duration of the heats was obtained even after 250-350 heats.

In high-capacity open-hearth furnaces operating the scrap-ore process with a high proportion of hot metal in the charge, the conditions of loading the solid charge, adding the hot metal and running off the slag during the melting period are of considerable importance for the normal steelmaking process. Although at the majority of large open-hearth plants of southern works, standardization of the charge has been adopted in principle, rational and standard furnace-charging conditions have not been adopted at many works.

Careful heating of the loose materials layer by layer assists in reducing fluctuations in the quantity of slag run off and in speeding up the melting process, as well as the production of a more homogeneous composition of metal and slag after melting; it is therefore not accidental that, at the Kuznetsk Metallurgical Combine, where every portion of the loose charge is thoroughly heated, the melting period is 15-30% less than in similar types of furnaces at other works.

The absence of uniformity in charging conditions is due not only to a failure to appreciate the technical significance of this operation, but also to the unsatisfactory organization of the supply of raw materials to the furnaces. The successful supply of open-hearth furnaces with raw materials is largely determined by the proper organization of the movement of trains not only in the stockyard itself, but also between the stockyard and the furnace bay. The most rational system of movement in supplying charge materials to open-hearth furnaces, as in any other department of a modern metallurgical works, must be considered to be the continuous flow system, which excludes counter-traffic, simplifies shunting operations, eliminates interruptions in loading the charges, ensures the possibility of weighing empty cars on each turn around and reduces the standing time of empty and loaded trains.

At a number of southern works, however, while a tendency has been shown to carry out the continuous flow method, there has been a confused and insufficiently rational system of rolling stock movement.

It is obvious that the most rational continuous flow system of the supply of charge materials can be realized if the loose materials and scrap are kept in separate stockyards, but even in existing stockyards, counter-traffic of loaded and empty trains can be reduced to a minimum.

For this purpose, it is preferable to load the loose materials for charging the furnaces from one group of bunkers or bins, while the materials for refining and finishing are loaded from another group of bins. All loaded trains should be sent out from one side of the stockyard, and the empty trains should enter at the other side. Trains with materials for refining and finishing only will in this case be sent to the steel plant on the "pendulum" principle, but by a separate road, independent of the flow of charge materials. To carry this into effect requires the organization of a suitable allocation of materials in the bins and the provision of additional track switches.

As is well known, in plants with 370-ton furnaces, trains with loose materials for charging the furnaces are not put between the furnaces, and there they interfere with operations at adjacent furnaces. Due to this, there are involuntary losses of time between the end of finishing the heat and the commencement of loading. To eliminate these losses, it is preferable not to load the loose materials in charging boxes but in special bins or bunkers, as has been done at the Magnitogorsk Metallurgical Combine, following the proposal of Engineer Ovsyannikov and as is currently being adopted at the Kirov and Dzerzhinsky works. The use of bunkers or bins enables the loading effort at the stockyard to be better utilized and the loading time to be reduced. The supply of refining materials in the same bunkers mounted between the furnaces eliminates the delays in commencing the purification of heats, reduces the number of charging box trains and simplifies shunting.

Increasing the capacity of the charging boxes to 1.75 m^3 (while retaining the present number of cars in the train) reduces the number of trains with scrap for each charging period.

It is necessary to plan the work of the stockyard with reserves, independently of the heat-tapping program. Interchangeable (standard) trains should be loaded with loose materials and metal scrap so as to ensure a reserve of loaded trains in the stockyard sidings.

To ensure standard operation of the heat, considerable importance attaches to uniformity in the hot metal composition, to observing a definite duration of the heating period after charging and to the length of time taken for adding the hot metal.

Despite the smaller amount (1.5 times less) of hot metal supplied by the mixers per day, the degree of loading of the mixer cranes at southern works is not much less than the mixer crane of the Magnitogorsk Metallurgical Combine (comparison with the Kuznetsk Metallurgical Combine is inappropriate, since at the latter works, there are two mixer cranes). This is due primarily to the fact that at southern works, the mixer cranes are used on a number of operations connected with the treatment of the ladles (breaking up the slag, preparation of the nozzle, knocking out the ladle). A considerable amount of time is spent on these operations at the Kirov and Voroshilov works, where the full cycle of servicing a ladle is 1.6-1.8 times longer than at the Magnitogorsk Metallurgical Combine. In addition to this, the principal rate of lift of the mixer cranes at southern works is from 10-30% less that at the Magnitorgorsk and Kuznetsk Metallurgical Combines. To increase the capacity of the mixer cranes, less slag should be allowed to get into the ladles at the blast-furnace iron tapholes. It is also necessary to consider the question of increasing the speed of the primary lifts of mixer cranes to 4.5-4.7 instead of 3-4 m/min.

Furthermore, for improving the uniformity of composition of the hot metal, taking further increases in production into account, it is necessary to consider the construction of second mixers for open-hearth steelworks having a production of more than 2 million tons of steel per annum.

It is possible to achieve well-timed and rapid addition of hot metal by using three or four hot metal cars, observing a definite sequence in the addition of hot metal to the furnaces and also by using ladles of such a capacity as to ensure that all the hot metal required in a 185-ton furnace is added by means of two ladles and in a 370-ton furnace, by means of three ladles. These requirements, which are easily met, are not however, always satisfied. Simultaneous addition of hot metal to two or three furnaces leads to an appreciable increase in length of this period of the heat.

At a number of works, the principle of successively adding hot metal to the furnaces is disturbed without any real reason and not infrequently the hot metal is added to two or three furnaces simultaneously. The supply of hot metal to the furnaces is also rendered difficult by the fact that the hot metal roads are often blocked with various materials and are used for the transport of other loads.

Standard conditions of adding the hot metal and constant duration of heating the charge and adding the hot metal ensure a standardized melting operation and slag formation and facilitate slag runoff during the course of melting. The state of the slag holes and the sequence of running off the slag are, however, of no little importance in this respect.

At the Kuznetsk Metallurgical Combine, the period of slag runoff is strictly regulated: 10-15 minutes after charging the hot metal, the slag openings are opened, and slag is flushed through the charging doors only after the slag ladles have been filled in the casting bay. At a number of works, a start is made with running off the slag through the slag holes immediately after addition of the hot metal is completed or even before it is completed. Flushing of slag through the charging door is commenced before the ladles in the casting bay have been filled. As a result of this, at a number of southern works, less slag is run off during the melting period than at the Kuznetsk Metallurgical Combine, despite the necessity for removing a larger quantity of slag (in view of the nature of the ore).

An important condition for regular operation of open-hearth furnaces is adequate capacity of the casting bays and ingot yards.

Experience at leading works and calculations show that for determining the necessary number of casting cranes in modern open-hearth steelworks with high-capacity furnaces, it is essential in practice to start from a standard of say 1100 tons of steel cast per day for a crane having a load-lifting capacity of 260 tons. At a number of works in the south, 600-900 tons are cast per crane. The casting cranes at the Kirov and "Azovstal" works, however, have to execute all operations in servicing the ladles, covering the ingots of rimming steel, unloading (and transporting) mold additions, etc., and at the "Zaporozhstal" and Dzerzhinsky works, performing some of these operations, which increases the loss of crane time by 8-12% (per heat) compared with the figures for the Kuznetsk Metallurgical Combine and the Magnitogorsk Metallurgical Combine.

For putting the stoppers in ladles, adding deoxidizers and ladle repair work, it is best to use bracket cranes moving along the crane track girder of the casting bay, and for making ingot additions and putting caps on the ingots, walking or velocipede cranes on the casting floors.

Bracket cranes should be provided at all open-hearth steelworks having large-capacity furnaces, where the construction of the crane-track girder permits. If such cranes cannot be provided, slewing bracket cranes should in any case be provided for the repair pits, as has been done at the Kuznetsk and Magnitogorsk Metallurgical Combines.

Despite the fact that the ingot yards in the south are long and the crane equipment is better than at the Kuznetsk and Magnitogorsk Metallurgical Combines, they scarcely guarantee even the current level of production. This is due to the fact that at most southern works, up to now all the steel has been bottom cast; the amount of crane time and labor expended on the preparation of a single bogie train for killed steel is 2.5 times and on the preparation of a train for rimming steel, it is 3-4 times that required for the preparation of trains when top casting is used.

The Dzerzhinsky and Voroshilov works are currently going over to top casting of a number of killed steels. Even with the present method of casting, however, all southern works should be able to increase the capacity of the ingot yards by watching the flow of traffic and preparing the trains.

The independent flow of traffic in the long mold yards with side loops and with all the steel bottom cast (Kirov and Voroshilov works) may be organized with a certain loss of floor space after laying loops in the middle of the mold yard of the 4th road with exit into a side loop. Changing over to top casting of all killed steels make it possible to organize an independent traffic flow on each section of the mold yard, even without constructing these loops.

To avoid traffic counter-flow of trains, the movement of ingot trains from the casting bay to the ingot-stripping section should occur on only one of the roads between the casting bay and the ingot-mold yard, and trains which are proceeding to preparatory work and auxiliary trains should bypass the ingot-mold yard. In the same way, separate roads should be reserved solely for transit to the ingot-stripping yard.

At works where killed steel is bottom cast, it is a good thing, after removing the hot tops and stripping the ingots, to transfer the ingots together with the molds to auxililary trains for transport to the rolling mill. This speeds up the return of trains with bottom plates for preparation work and provides the possibility of mechanizing the cleaning and greasing of the ingot molds on the auxiliary trains before they are placed on the bottom plates.

The regular working of an open-hearth steelworks depends essentially upon the accepted order for the repair program of the furnaces and the execution of this program. With correct planning, it is possible to ensure that repairs will be distributed regularly with regard to time, and to eliminate the occurrence of repairs being carried out simultaneously at two or more furnaces.

This is commonly known, but is not yet fully put into practice. In addition to unexpected stoppages, due to unsatisfactory working conditions or failure to carry out at the proper time preventative hot repairs, the periods of stoppages, compared with the program, are prolonged if the furnace, due to its condition, can still be laid off for a time. Thus in 1956, the monthly program for stoppages of furnaces for cold repairs (with a variation of ± 2 days) was maintained to the extent of 50% at the "Zaporozhstal" works, 45% at the "Azovstal" works, 33% at the Kirov works, 29% at the Voroshilov works and 19% at the Dzerzhinsky works. Matters are still worse with regard to extensive preventative hot repairs. All this unavoidably results in a disturbance of the regular working of the steelworks and delay in repairs, due to the dispersion of the repair crew effort.

The duration of repair work is increased due to inadequate preparation and insufficient mechanization of the work. Some work, which ought to be completed before the furnace is laid off (erection and testing of all the machinery used in repair, transport and rational stacking of all the bricks required for the repair, taking into account the order in which they will have to be used in the furnace, supply of water and compressed air, etc.), is often incomplete.

The mechanization of repair work is of no less significance. Unfortunately, in drawing up the plans for restoration and for the construction of new furnaces, formerly no plans were worked out for the mechanization of repairs, and metallurgical works considered this to be a matter of secondary importance. This is the only explanation which can be given to the fact that up to the present, complete, permanent mechanization of repairs obtains

at only one southern works, the Dzerzhinsky works. This is not yet completed at the Kirov, "Zaporozhstal," Voroshilov and "Azovstal" works.

In addition to the steps enumerated in the foregoing for ensuring regular working of open-hearth furnaces, no little significance attaches to drawing up a daily furnace-tapping program (graph) and taking active steps to see that it is carried out.

In planning the tapping of heats at the Kuznetsk Metallurgical Combine, efforts are made to ensure an interval of 2-3 hours between the tappings of two alternate heats in 370-ton furnaces, and 2-2.5 hours in 185-ton furnaces, at the "Zaporozhstal" works, not less than 30 minutes and at the Magnitogorsk Metallurgical Combine (plant No. 3), not less than 1 hour. To obviate coincidence of heats at the Kuznetsk Metallurgical Combine, provision is made for a rational distribution of heats among the furnaces and extra stoppages for repair of furnace bottoms; at the Magnitogorsk Metallurgical Combine, in addition to these steps, commencement of charging is delayed in exceptional cases, and at the "Zaporozhstal" works, the oxygen supply to the furnaces is varied.

At the Kuznetsk and Magnitogorsk Metallurgical Combines and at the "Zaporozhstal" works, active steps are taken to see that the program is completed, and in addition, a systematic analysis is made of the work according to the program.

At a number of other works, the foregoing requirements are not fully met. A fundamental change is required in the attitude to questions of drawing up the programs and their operative control.

The statements made in the paper by no means exhaust the whole range of problems concerning the organization of production in open-hearth steelworks having high-capacity furnaces. The adoption of the steps enumerated, which are directed towards improving the production organization and are based on the experience at leading works, ought to help to increase the productivity of open-hearth steelworks.

THE THERMAL PROCESS TAKING PLACE IN AN OPEN-HEARTH FURNACE DURING OXYGEN MELTING

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"Azovstal" Works

The experience gained in blowing oxygen during the melting of railroad rail steel and ordinary carbon steel and the study of the operation of the open-hearth furnace shops at the "Azovstal" works enabled reliable data to be obtained on the thermal process taking place in 350-ton open-hearth furnaces during the melting and refining of steel, as well as on temperatures observed during these periods.

The intense heating of the metal and the furnace lining during the blowing of oxygen onto the bath is due to the reaction heat generated by the oxidation of the iron and other charge components and to the heat produced by the combustion of carbon monoxide formed in the bath. The oxidation reactions are effected by the oxygen introduced into the metal and the gaseous oxygen.

At the "Azovstal" works a method has been developed in which the optimum conditions are created for melting the charge by the use of oxygen, which produces a sharp rise in the temperature of the metal, and achieves a rapid melting of the charge. During the blowing of oxygen the temperature rises sharply in the first hour after the hot metal has been charged and remains at a level 50-60°C above that of an ordinary heat during the first 2-2.5 hours. Toward the end of the melting period the temperature difference decreases (Fig. 1.)

The rapid increase of the temperature of the metal which accompanies the blowing of oxygen during the melting period calls for an accurate control of the furnace temperature in order to prevent the overheating of the roof and lining. In the course of special experimental heats which involved the introduction into the bath of considerable quantities of oxygen, a method was tested in which the coke-oven gas consumption during the

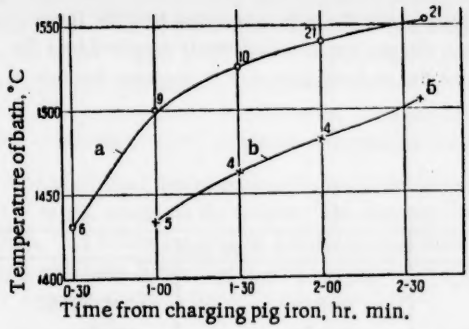


Fig. 1. Variation of the metal temperature during the melting period. a) Heats with the injection of oxygen; b) the same, without the injection of oxygen (figures show the number of investigated heats).

TABLE 1

Influence on the Melting Process of Various Methods of Blowing Oxygen

Characteristics	Method of blowing	
	into flame and bath	only into bath
Number of heats	7	10
Average thermal load during the melting process, in mil. cal/hr	27.0	24.7
Oxygen consumption during the melting period, in m^3	5160	3270
including: into flame	3460	660
into bath	1700	2610
Duration, in hr-min:		
charging of hot metal	0-40	0-48
melting	3-05	2-40
Oxidation rate, in % per hr:		
carbon	0.56	0.65
phosphorus	0.34	0.40
Content in molten metal, %:		
carbon	1.31	1.31
phosphorus	0.112	0.136
Temperature of molten metal, in °C	1523	1531

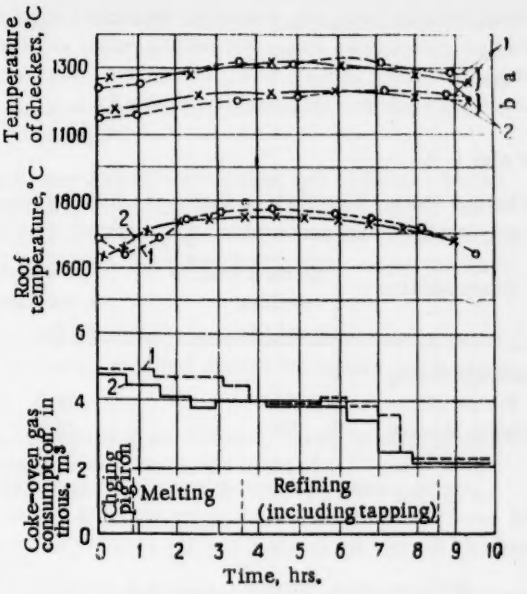


Fig. 2. Variation of roof and checker temperature due to the supply of oxygen during the melting period: 1) simultaneous supply of oxygen into the flame and bath; a) checker chamber on blast; b) checker chamber on gas.

TABLE 2

Composition of Combustion Products in the Case of Oxygen Blown onto the Bath

Consumption, in thous. m^3/hr			Theoretical coefficient of air excess	Composition of combustion products, (%)			No. of gas samples
Coke oven gas	Blast-furnace gas	Air		CO_2	CO	O_2	
5.5	7.0	42.0	1.40	22.0	0.4	0.2	2
5.0	7.0	43.5	1.60	17.7	0.0	2.0	3
4.0	6.5	40.0	1.70	13.5	0.0	4.6	4
2.7	6.5	43.0	2.30	18.0	0.0	4.5	3

melting period was reduced by about 25% from the usual 4800 m^3/hr to an average of 3400 m^3/hr. These experiments indicated that the length of the melting period and the rate of oxidation of carbon are practically unaffected by the cut in the supply of coke-oven gas.

When the rate of consumption of coke-oven gas was 3400 m^3/hr, the roof temperature during the melting never exceeded the permissible values which occasionally occurred when the rate of consumption was 4600 m^3/hr. In addition, when the average coke-oven gas consumption was 4600 m^3/hr, the rate of removal of phosphorus was lower and the phosphorus content of the metal on the completion of melting was higher than was the case with reduced gas consumption.

Two series of experimental heats were made in order to investigate the usefulness of the simultaneous blowing of oxygen into the flame and onto the bath during the melting period; during the first series the oxygen was

blown onto the bath only, but during the second series it was blown onto the bath and added into the flame. Oxygen consumption during the melting period was higher when the gas was simultaneously supplied into the flame and blown onto the bath. This failed, however, to reduce the melting period or to increase the rate of oxidation of carbon and phosphorus (Table 1).

TABLE 3

Thermal Process Taking Place During the Refining Period

Characteristics	Working		Pure boil	
	thermal load, in million cal/hr	air consumption, in thousand m^3/hr	thermal load, in million cal/hr	air consumption, in thousand m^3/hr
Average during the period	27.1	34.2	25.1	34.1
During blowing	20.1	41.0	19.5	40.2

Figure 2 shows that in both cases the temperature of roof and checker is about the same. It will, however, be noted that during the simultaneous supply of oxygen into the flame and bath it has not been possible to avoid a rise of the roof temperature over the permissible value.

In the practice, therefore, oxygen is not blown into the flame at the same time as it is blown onto the bath.

Investigations consisting of a number of experimental heats were carried out to determine the necessary amount of air blast when oxygen is blown onto the bath.

Table 2 shows that if the process is conducted with the theoretical coefficient of air excess not below 1.6, the carbon monoxide formed in the bath during the melting process is completely burned and the atmosphere in the furnace becomes oxidizing. A reduction of the calculated coefficient of air excess to 1.4 results in incomplete combustion of carbon monoxide.

If oxygen is injected into the bath, the air blast is regulated during the melting process in such a manner that the coefficient of air excess at the valve is not less than 1.6.

If oxygen is injected into the bath during the refining period, a considerable overheating of metal is observed even at reduced thermal loads. In order to avoid this, in the cases when carbon content is 0.8-2.0%, the injection of oxygen is combined with the addition of ore.

During the refining period when oxygen is blown onto the bath, the supply of coke-oven gas is reduced on the average by about 25% as compared with the normal consumption, while the air blast, far from being reduced, is slightly increased to ensure a complete combustion of the carbon monoxide produced in the charge (Table 3).

In the case of the roof temperature rising above the permissible value, the consumption of coke-oven gas is cut to less than half.

During the refining period oxygen is not ordinarily added to the flame at the time it is introduced onto the bath.

NEW METHOD OF MAKING HEARTHS OF BASIC OPEN-HEARTH FURNACES

Cand. Tech. Sci. M. S. Sokolov and Engineer P. P. Semenenko

It is known that the hearth is one of the most important parts of a basic open-hearth furnace. Both the furnace output and the quality of the steel produced depend to a considerable extent on the conditions of the hearth.

In this country the working part of the hearth consists mainly of magnetic firebrick, and a comparatively thick sintered layer; abroad it is usually of magnesite and sometimes partly of chrome-magnesite firebrick,

rammed course, and a thick sintered layer. This method of construction shows that the more active role in the operation of the hearth is played by the sintered layer and not by the firebrick. Comparing the main properties of the burnt-in layer and the magnesite brickwork, it can be said that the properties of magnesite are better than those of the sintered mass. For instance, a magnesite brick containing 85% of magnesium oxide resists about 2000°C, while the sintered or rammed magnesite withstands 1700-1800°C.

The good qualities of magnesite brick are as yet virtually not used to reduced stoppages in furnace operation due to the repairs to the hearth. The existing methods of laying magnesite hearths have some serious shortcomings. The bricks are laid on powdered magnesite, which does not sinter and combine with the refractory mass, and as a result the liquid metal penetrates gradually into the joints between the bricks. For this reason the brick course is covered with a burnt-in or rammed layer.

This penetration of metal renders the repair of the brick layer difficult; it increases the amount of repair work and reduces its quality; it increases the possibility of the escape of metal through the bottom and increases the number of stoppages for the repair of holes in the hearth.

After the completion of extensive research work on the reduction of wear in open-hearth furnaces carried out in 1944-1947 at the "Serp i molot" Works, it was suggested that the bottom and banks of the furnace should not be built up on the powdered magnesite only, as it is usually done, but on a "sintering" filling which, owing to its sintering and diffusion into the refractory, "welds" the lining into a monolith.

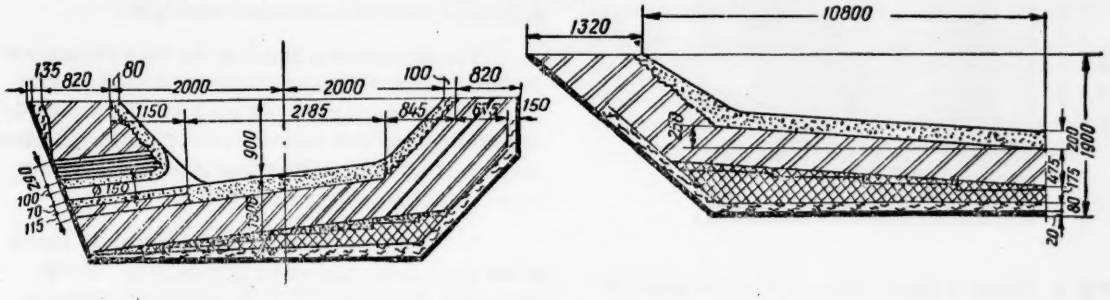


Fig. 1. Longitudinal and transverse sections of the hearth of the No. 4 open-hearth furnace.

It will be noted that the work on the development of the solid magnesite hearth continued for a long time. For example, Professor V. E. Grum-Grzhimailo suggested that the magnesite should be bonded with dehydrated resin, which protects the hearth better against the penetration of the metal and prevents the oxidation of the metal which has penetrated into the joints. In the opinion of V. E. Grum-Grzhimailo, the existence of oxidized metal in the joints was one of the main reasons for the breaking-off of the sintered mass and for the penetration of metal into the lining. Professor M. E. Pilnik suggested the use of a mixture of powdered magnesite with water glass as the bonding agent for the brick part of the hearth. It was also suggested that block and herringbone bonds should be used in laying the hearth.

However, because of their complicated nature and the difficulty of application, none of these suggestions has found extensive use. The use of "welding" fillings, however, is easy and simple and requires no change in the usual procedure of making the hearth.

In 1948 at the Serov Metal Works "welding" filling consisting of a mixture of powdered magnesite and roll scale was used in making the hearth of the No. 4 140-ton basic open-hearth furnace. Roll scale was used exclusively to minimize the adverse effect of reducing gases upon the magnesite. Other more readily-melting oxides, for instance, slags or synthetic mixtures, can also be used as the "welding" filling.

The construction and dimension of the experimental hearth of the No. 4 furnace are given in Fig. 1. The method of laying the brickwork of the hearth is illustrated in Fig. 2, in which the outline of the burnt-in layer is indicated by a dotted line.

"Welding" filling of various types was used in the magnesite hearth: in the bottom of the hearth, where the first courses of bricks were laid flat, the filling consisted of 20 vol.% of roll scale; when the bricks were laid

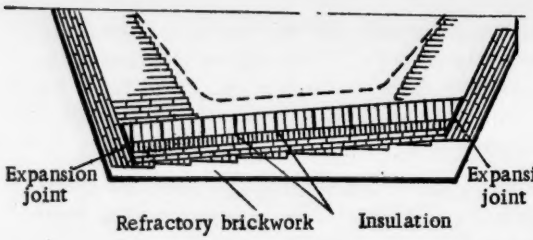


Fig. 2. Method of laying bricks in the hearth of the No. 4 furnace.

Fig. 3. Pieces of metal extracted from the joints of the hearth brickwork of the No. 3 open-hearth furnace.

edgewise (3rd layer), the percentage of roll scale was 15, and when the bricks were laid upright (4th layer), it was 10%; while in the banks 50% roll scale was used. The hearth was then coated with roll scale slag and subsequently with open-hearth furnace slag. The formation of roll scale slag layer lasted 8 hrs, 20 min and the formation of open-hearth slag layer – 4 hrs, 15 min; 4 tons of roll scale and 2 tons of open-hearth furnace slag were used in the process; the brickwork absorbed 1600 kg of roll scale. It will be noted that in the record of the open-hearth process the lining of the No. 4 furnace was the first to be "slagged" with roll scale.

The burning-in of the hearth was carried out by a method adopted at the works; 14 layers of about 15 mm in thickness, making a total of 200 mm, were applied; the process lasted 81 hrs, 20 min. The first two layers had an increased content of iron oxides (30-31%), and a reduced magnesium oxide content (48-50%). On the whole, the work was carried out well and in full agreement with the usual works instructions.

The experimental hearth of the No. 4 furnace was in operation for 7 years and 2 months and was used for melting steel of all grades. It was employed especially in melting steels with lower content of alloying elements only after high alloy steels began to be melted in furnaces with chrome-magnesite foofs.

During the repeated testing in 1955 of the hearth of the No. 4 furnace in which the "welding" fillings were used, the "slagging" of the magnesite brickwork with roll scale gave, as it did in 1948, promising results – no breaking-away of the burnt-in layer and no escape of charge occurred. As compared with the other furnaces of the shop, the hearth of the No. 4 furnace required 9% less repairs during the whole campaign.

During the demolition of the walls and banks of the hearth of this furnace, it was found that with the use of the "welding" mix, the penetration of metal into the brickwork joints was insignificant in comparison with the hearths of the other furnaces. In contrast to the No. 3 and No. 6 furnaces, where a very considerable penetration of metal into the ordinary magnesite brickwork was observed (Fig. 3), in the No. 4 furnace the metal penetrated to a depth of 100-200 mm in place where apparently no sufficient amount of the "welding" filling was present. The thickness of "welded" layer on the experimental hearth varies: in the top rows of the walls and banks the "welded" layer is 50-70 mm thick; in the bottom layers (including the hearth bottom), its thickness is greater. The reasons are: the nonuniform distribution of temperatures over the thickness of the hearth (Fig. 4) and the high melting point of roll scale (1530-1550°C).

The use of "welding" filling reduces the adverse effect of the incidence of joints in the different rows of brickwork and of the defects due to difficult joints in the corners of the brickwork; it also enables the hearth to be made exactly in accordance with the contour of the bath. This is particularly important in view of the introduction of the use of oxygen in the open-hearth process and the need to make deep baths which resist scouring better. The fact that there is little metal in the joints enables the bricks easily to be separated from one another, thus making repairs considerably easier, faster and of better quality (especially in places where the new and old brickwork meet) and at the same time permits a saving in magnesite bricks. Provisional calculations show that the use of "welding" filling permits in magnesite brick alone a saving of 0.2-0.3 kg per 1 ton of steel produced.

It will be noted that owing to the existence of a thick-sintered layer (200 mm), it has not been possible to take full advantage of the good properties of welded hearths, especially with regard to the reduction of stoppages due to hot repairs of the hearth.

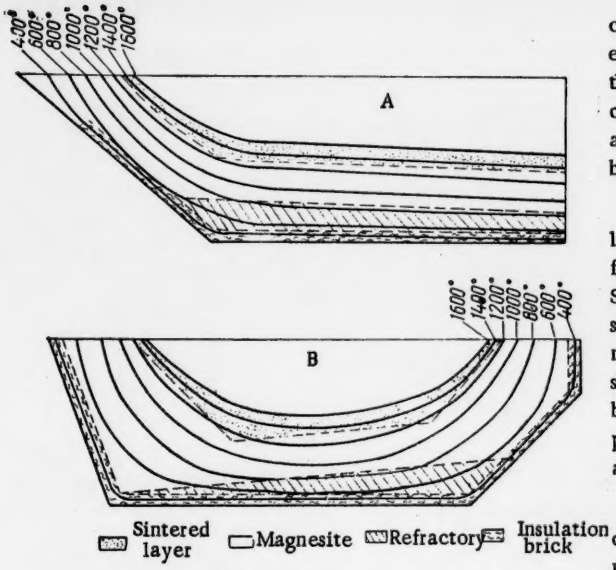


Fig. 4. Distribution of temperature in longitudinal (a) and transverse (b) sections of the hearth of the No. 4 furnace (the temperatures are determined by electric method on flat models).

At present, at the Serov works, work is being continued on the more accurate determination of the economic effect of the use of "welding" fillings; on the increase of thickness of the welded brickwork layer; on the reduction of the thickness of the sintered layer; and on the establishing of a type of brickwork with a better resistance to the attack of slags.

In an American journal* a description is published of a new design of hearth for basic open-hearth furnaces tested in the melting shops of the Bethlehem Steel Corp., the general idea of which is about the same as that of the method of the Serov works. The new American hearth is illustrated in Fig. 5, which shows that the hearth consists essentially of magnesite brickwork with a thin (75-125 mm) sintered layer. The physical and chemical properties of such a hearth are about the same throughout its thickness.

Magnesite bricks with a high magnesium oxide content (about 90%), burnt at high temperature, highly moisture-proof and with a high specific gravity (2.9 ton/m^3), are used in the hearth. These values are considerably higher than the corresponding figures for the magnesite brick made in this country. The hearth consists of three layers of bricks and its total thickness is

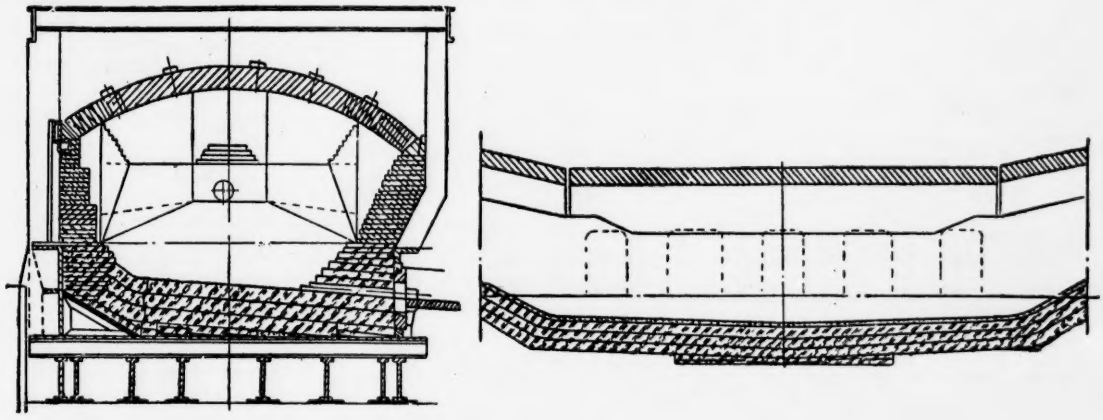


Fig. 5. Longitudinal and transverse sections of a new American hearth for a large open-hearth furnace.

710 mm. The joints are filled with periclase, which softens at a temperature of about 1100°C. It is pointed out in the article that the plascitity and density of the filling are the same in all joints. The use of an all-magnesite hearth in place of a more labor-consuming and less satisfactory rammed construction results in a considerable reduction in the time needed for repairs and burning-in; it rends the laying of brickwork much simpler and enables the warming-up of the hearth to be carried out at a higher rate (up to 10°C per hour). It is also pointed out that hearths with a greater wall thickness (over 710 mm) must be considered to be of faulty design.

Figure 5 shows that the front wall of the hearth, which, as a rule is heavily penetrated by metal, is made of a different refractory (apparently of a lower quality) than the bottom of the hearth.

* Industrial Heating, 23, 11, 2432-2436 (1956).

This may be due to the fact that American practice has not as yet adopted a method of preventing the penetration of liquid metal into the brickwork of the front wall, and this part of the hearth requires frequent repairs.

The American article does not contain sufficient technical data to permit an easy construction of the hearth, but even so it is of considerable interest.

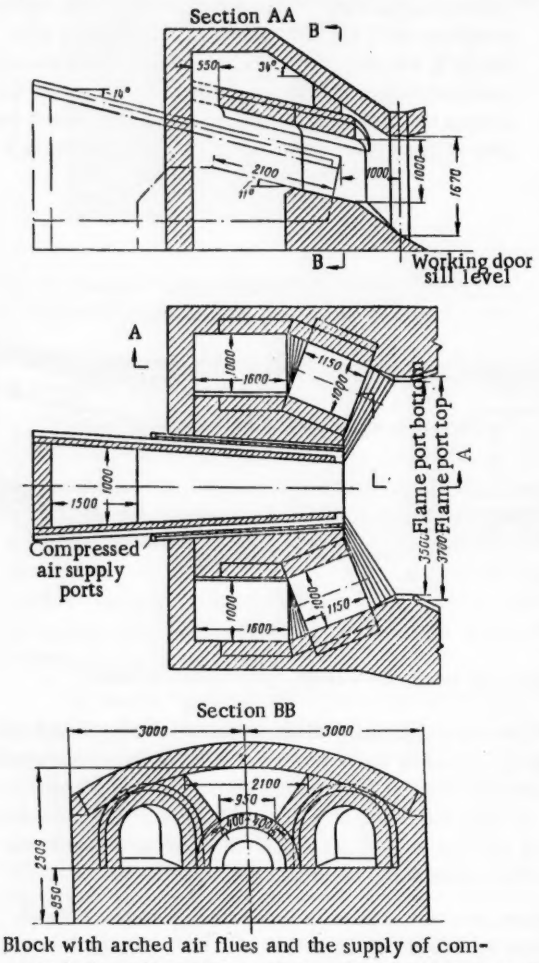
The experience of the Serov Metal Works and the published American data will serve as a basis for the development of more durable and efficient hearths for basic open-hearth furnaces.

IMPROVED BLOCKS OF OPEN-HEARTH FURNACES

A. P. Klyucherov and L. V. Makogonov

The Nizhny Tagil Metal Combine

Since 1954 a new bulkhead with arched air flues, developed by a team of technicians of the works, has been used in some of the Nizhny Tagil Metal Combine 140-ton open-hearth furnaces, fired with mixed (coke-oven and blast-furnace) gas.



Block with arched air flues and the supply of compressed air at the periphery designed at the N.T.M.K.**

From the uptakes in this bulkhead, air is fed into the working space by three flues; the floors of the two arched side flues are at the same level as the gas flue and run at an angle of 11° to the bath plane, and a top flue is located above the coffer (see figure). The front part of each of the arched flues is carried on two water-cooled 3 in. diameter tubes.

At the same time that the construction of the air flues was altered, two 1.25 in. diameter compressed-air pipes were installed in the block, one on each side of and in the top part of the gas flue.

This is not the first time that compressed air has been supplied into the flame of the open-hearth furnaces at this works. For instance, during 1953-1954, in one of the 140-ton furnaces with blocks designed by K.M.K.*, compressed air was fed through a 1 in. injector into a small air port arranged underneath the gas port; the injection action of the compressed-air jet produced a considerable improvement in the aerodynamic properties of the flame which resulted in an increased output by the furnace and some economy in fuel consumption per ton of steel melted. Compressed air supplied at gas ports also had a favorable effect upon the output of the furnace and the wear of arches.

However, the supply of compressed air at the periphery which was first used in furnaces with arched blocks and later in Venturi blocks proved most effective.

The supply of air at the periphery considerably improved the aerodynamic properties of the flame; this facilitates operation at higher thermal loads during

* Kuznetsk Metallurgical Combine.

** Scientific and Technical Machinery Committee.

Operational Characteristics of 140-Ton Open-Hearth Furnaces with Different Blocks

Characteristics	Type of block				Mean values for block with compressed air supply at the periphery
	Venturi, without compressed air supply	Narrow-port with compressed air supply	Venturi, with compressed air supply	Arched-port, with compressed air supply	
Number of campaigns	9	2	3	5	8
Length of period, in hours:					
preparation	0.46	0.47	0.53	0.47	0.50
charging	1.48	1.46	1.40	1.41	1.40
heating	1.53	1.58	1.53	1.49	1.50
melting	3.38	3.03	2.88	2.87	2.87
refining	2.74	2.53	2.40	2.32	2.35
Thermal load at various periods, in million cal/hr:					
preparation	15.0	14.7	16.2	16.6	16.4
charging	19.7	19.9	20.7	21.0	20.9
heating	19.0	18.8	20.5	20.8	20.7
melting	16.2	17.2	17.7	18.5	18.2
refining	16.5	16.5	17.7	19.1	18.5
Service life of roof, in No. of heats	263	249	278	279	279
Average length of a heat:					
in hours	9.59	9.07	8.74	8.56	8.62
in %	100	94.6	91.1	89.2	89.9
Hourly output during actual operating time, in %	100.0	107.1	109.5	111.5	110.9
Average thermal load per heat:					
in million cal/hr	17.2	17.6	18.6	19.4	19.1
in %	100.0	102.3	108.1	112.7	111.0
Consumption of standard fuel:					
in kg/ton	167.0	159.8	165.3	169.0	167.5
in %	100.0	95.7	98.9	101.1	100.3

all periods of the melting process and especially during the melting period, and it also enables the furnace to be operated with a reduced coefficient of air excess.

As a result, the output of furnaces equipped with Venturi blocks increased during the actual operation time by 9.5%, and that of furnaces with arched bulkheads by 11.5%, with the fuel consumption per ton of steel remaining the same (see table). Owing to the improved shape of the flame, the life of the roof increased by an average of 6%, with a simultaneous slight reduction in stoppages for hot repairs.

Special features of the block with arched flues are: a smaller cross sectional area of air flues which results in increased air velocity; greater length of the flues (this improves the stability of the flame); and the relatively low position of the hot air ports in relation to the bath surface. The supply of compressed air at the periphery ensures a more uniform operation of the furnace during the whole campaign.

These advantages of a block with arched flues become fully effective only when the consumption of compressed air is not below 1200-1500 nm^3/hr.

A comparison of the operation of furnaces fitted with Venturi blocks and blocks of N.T.M.K. design with the same consumption and method of supply of compressed air shows that the use of the block with arched flues increase the average hourly furnace output by 2% and that owing to the reduced wear of brickwork and fewer and shorter hot repairs, the furnace output in nominal time increased 3.5-4%.

The service life of arched air flues made of chrome-magnesite brick, supported on special water-cooled tubes and supplying air into 140-ton furnaces (fitted with Dinas roofs) operating at thermal loads not exceeding 20 million cal/hr, proved satisfactory. It appears that an increase in the service life of blocks with arched flues at higher thermal loads would require the removal of coffers from the arched flues.

Editor's note. The article by A. P. Kylucherov and L. V. Makogonov is published for discussion. Readers are invited to express their views on the problem.

ROLLED PRODUCT AND TUBE PRODUCTION

THE ROLLING OF A SIDE-RING SECTION OF REDUCED WEIGHT

S. G. Terentyev

Chief Roll Designer of "Krasny Oktyabr" Works

For many years our works rolled a special section for the automobile side-ring. This was done on an ordinary light-section mill "325," which consisted of a three-high roughing stand and six finishing stands. The square blank (75 mm across) was 2.4 m long and weighed 100 kg.

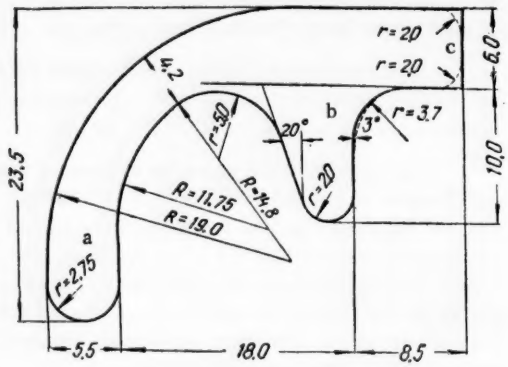


Fig. 1. Altered (light-weight) section for the side-ring of automobile wheel: a) leg of the section; b) nipple; c) heel.

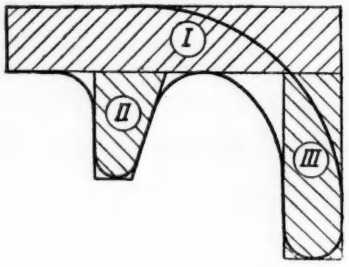


Fig. 2. Elements of the section.

When Gorky Motor Works suggested the putting into production of a side-ring section of reduced weight, the variant with a bent "leg" (Fig. 1) was adopted as the easiest to design and requiring the smallest number of passes. A few alterations were made in the original drawing in order to render the rolling conditions easier.

Although the original over-all dimensions were retained, the new section is 20-22% lighter than the original type.

In order to be able to test the rolls in the shortest possible time, it was decided to turn the grooves of the lighter section on the set of rolls of the previous section (new rolls were made for the finishing stand). The general layout of the rolling process and the number of passes were left unchanged.

In calculating the passes, the section was divided into its elements (Fig. 2); an equal rate of elongation was adopted in each pass for elements I and III, while for the element II it was greater by 0.04-0.07. No substantial difficulties were encountered in shaping the intermediate passes of the "heel" and "nipple" of the section, since the shape of these section elements and of the corresponding calculation elements were very similar.

The main difficulties were presented by the shaping of the leg which, in the calculation contour, was represented by two rectangular elements I and III but is bent in the design contour (outside radius 19 mm), and whose thickness varies from base to tip. In order to obtain for the leg in the intermediate shaping passes the rates of elongation which are equal to the calculation values, it was necessary to increase the outside radius of the leg in passes starting from the finishing pass to the beginning of the process. This, however, can hardly be achieved in practice. It is also unlikely that the equality of the rates of elongation can be obtained by calculation.

The use of different rates of elongation in the left-hand and right-hand parts of the section would result in the twisting of rods, incorrect filling of the grooves by metal, and in an inaccurate final section. In order to avoid

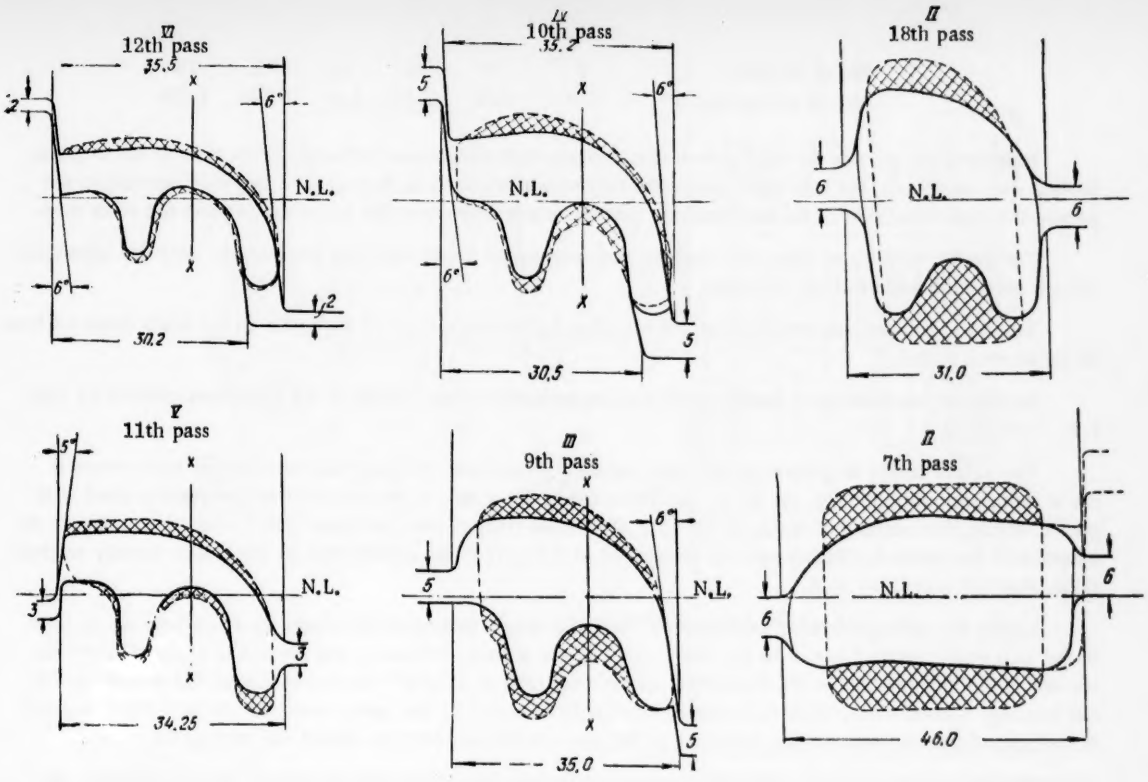


Fig. 3. Rolling operations of the light-weight side-ring section (arrangement of passes). Nos. of stands are indicated by Roman numerals.

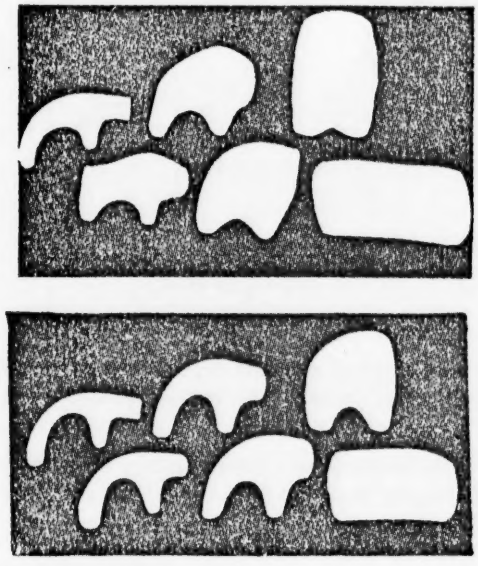


Fig. 4. Filling of passes by metal. Top) templets made in rolling the original section; bottom) the same, for the light-weight section.

this, a vertical axis X-X, which replaces the axis of symmetry, was drawn in each pass along the line where the leg joins the rest of the section. The contour of the section entering each pass was laid onto the contour of this pass in the same position in which it appears on the roll but in such a manner that the vertical axis X-X of both contours are coincident and that the horizontal axes passing through the centers of gravity of both sections approximately coincide.

The areas of the section to the left and right of the X-X axis of the pass and of the section entering the pass were carefully measured by means of a planimeter with the possible incomplete filling of the contour taken into account. The dimensions of the section entering the pass (mainly of its right-hand part – the leg) were then corrected until equal rates of elongation for both parts of the pass were obtained.

The final shape, dimensions, and the position of passes are given in Fig. 3; the rates of elongation are as follows:

No. of the pass	7	8	9	10	11	12
Rate of elongation, μ	1.23	1.22	1.30	1.30	1.235	1.215

In cutting the grooves for the light-weight section, errors which were detected in the rolls of the original section were removed; the left-hand part of the section was made so as to produce a negative opening in the passes, the right-hand side of the pre-finishing pass was made wider near the tip of the leg and not at its base.

The guides before and after each shaping pass were made to suit its shape accurately; they are adjustable in both horizontal and vertical directions.

Testing of the new sections was carried out after the daily overhaul of the mill; in 2.5 hours about 10 tons of metal were rolled.

Because of the inadequate length of the cooling beds (40 m) the weight of the blank was reduced by 20%, i. e., to 80 kg.

The actual filling of grooves with metal and their adjustment "to iron" can be observed from templets made during the rolling (Fig. 4). In the last three passes the nipple of the section was completely filled with metal, although no reserve of metal in the form of a "false flange" was provided; this is due, apparently, to the adoption of the somewhat higher rates of elongation in this part of the contour and to the predominantly vertical rather than sideways reduction.

During the rolling a substantial defect of the flat pass was detected. Although the smooth guides in front of the pass were mounted nearer to the thin portion of the section, the metal was pressed in rolling toward the opposite side; this resulted in the formation between the rolls of a "strip" running along the rod as soon as the roll bearings worked loose. This shortcoming was easily removed by the replacement of the open by closed gap in this part of the pass and a slight widening of the pass (as indicated by the dotted line in Fig. 3).

The light-weight section could be rolled with a smaller number of shaping passes; this is, however, not desirable when large quantities are produced, since it would result in a greater wear of grooves causing difficulties in rolling.

Owing to the difference in cross sectional areas of both sections, the output of the mill in rolling the light-weight section fell by about 20% as compared with the output in rolling the original section. The expected additional drop in output due to the increased use of labor did not take place.

TURNING ROLLS FOR CONTINUOUS BLOOMING MILLS

Engineer A. A. Tulupov (Magnitogorsk Metal Combine)

and Engineer Tsui Fun (Anshun Metal Combine, Chinese Peoples' Republic)

Experience gained in the operation of turning rolls, instead of the helical guides in the continuous blooming mill at the Magnitogorsk Metal Combine, has proved the usefulness of this change for the increased output of mills and the improvement of the surface of blooms.

An attempt to use turning rolls similar to those employed at the Magnitorgorsk Metal Combine in the "600" continuous blooming mill of the Anshun Metal Combine (Chinese Peoples' Republic) met with serious difficulties because the continuous blooming mills of these works are of different designs. The small distance between the stands of the continuous train (3000 mm between the roll centers) prevented the installation of turning rolls at the rear side of the stand as was done at the M.M.C.

The problem was solved by placing the turning rolls between the housings behind the working rolls (Fig. 1). The hollow turning rolls are made from old working rolls and are carried on steel shafts fixed in holders welded to the housings (Fig. 2).

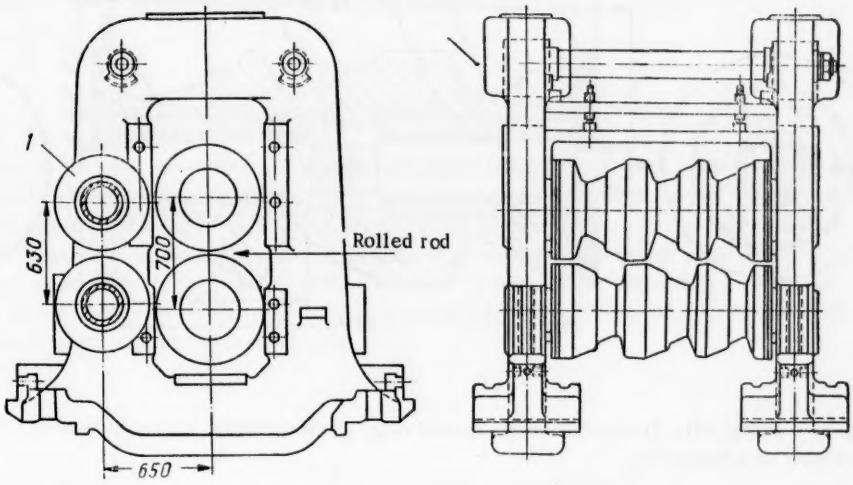


Fig. 1. The position of turning coils in the stand: 1) turning rolls.

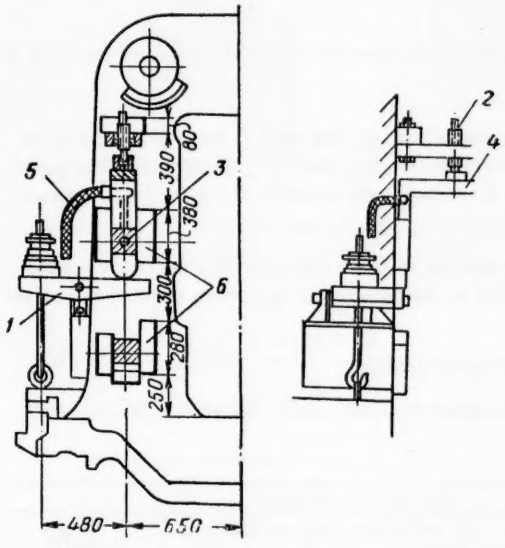


Fig. 2. The position of shaft holders. 1) Balancing device of the top roll; 2) adjusting (bottom) screw; 3) roll shaft; 4) bottom cross piece; 5) water-cooling tube; 6) shaft holders.

The shaft ends are square in cross section and are inserted into the holders from the side.

Initially the turning rolls had bronze bearings (bushes) with thrust ball bearings. The small distance between the stands (650 mm), however, required a large turning angle on a short length of the piece (turning angle 19°30') and produced a heavy pressure on the turning rolls in both radial and axial directions. In addition, difficult access to the bearings and the use of water cooling rendered the lubrication unreliable. As a result, scoring of the surface of the bronze bushes occurred after they were in operation for 1-2 shifts, and this was followed by the destruction of ball bearing housings, bronze bushes, and finally by the seizure of the roll bearings. Under these conditions the use of bronze bushes and ball bearings proved impossible.

The technicians of the blooming shop of the Anshun Metal Combine in cooperation with the Soviet engineers A. A. Tulupov and B. V. Mereckin overcame these difficulties by the employment of textolite bearings (bushes) and textolite thrust rings (Fig. 3). The shaft ends were case-hardened, while the end faces of turning rolls were ground. The supply of water into the turning rolls through its shaft ensured a reliable cooling of the textolite bushes and even of the side rings. In addition they get water from sprinklers, which cool the working surfaces (grooves) of the turning rolls. The textolite bushes are placed in steel casings and can therefore be easily replaced.

In the vertical plane the adjustment of the turning rolls is effected by means of a press-screw acting on the crossbar whose ends move the roll shaft holders and with them the roll. From below, the top turning roll is balanced by a spring device (Fig. 2).

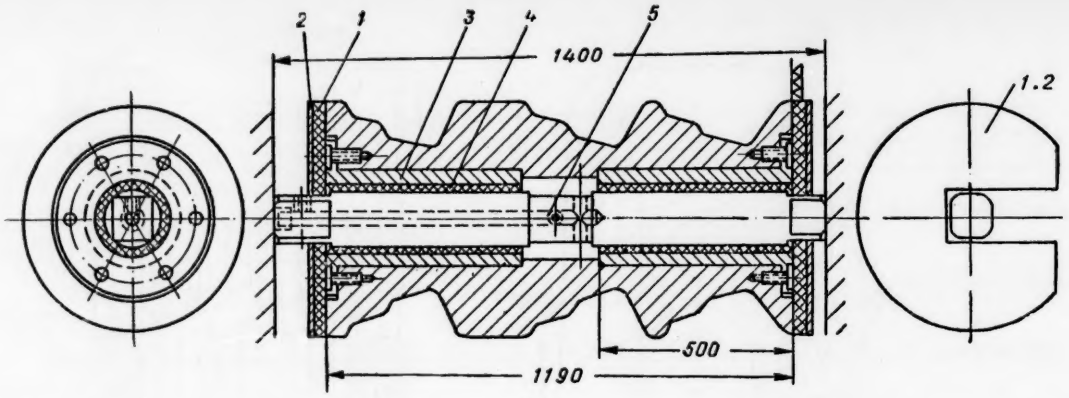


Fig. 3. Turning roll: 1) textolite ring; 2) steel ring; 3) steel casing; 4) textolite bush; 5) channel for the supply of water.

In the axial direction the position of the turning rolls is adjusted by means of textolite rings of suitable thickness (or by 2-3 thinner rings) supporting it on the thrust side.

A slit, corresponding in width to the square end of the shaft, enables the ring to be easily inserted and removed after the roll is slightly lifted by means of a lever. Thus the adjustment of turning rolls during the operation of the mill presents no difficulties.

In order to ensure a uniform pressure over the entire area of the textolite ring, a steel ring of the same shape is inserted between the textolite ring and the shaft holder.

There is one more point of difference between the designs of turning rolls used at the A.M.C. and those used by the M.M.C. At the A.M.C. there are no guides between the working and the turning rolls. The piece leaving the working rolls is received directly by the pass of the turning rolls and then along the usual channels directed into the pass of the next stand.

There is no need to change the turning rolls when the working rolls are changed; this enables the total time for changing the rolls to be reduced by 20-30 min, owing to the omission of operations connected with the removal and setting up of the helical guides.

The worn working sufaces of the turning rolls are built up by welding.

The turning rolls of the described design have been in operation at the A.M.C. for 18 months and have shown the following results.

No. of stand	Bloom cross section, in mm	Turning angle	Service life, in shifts			
			grooves	textolite bushes	textolite rings	shafts
1	250 ×183	19°30'	180-200	180	180-200	No signs of
3	216 ×132	19°30'	200-250	and more	200	wear detected

REPAIR OF MILL TABLE BEDS

V. F. Ivanov

Assistant Chief Maintenance Engineer of the "Azovstal" Works

Rather rapid wear of outer ring bores is observed in the operation of modern blooming mill roller tables, the roller journals of which are carried in antifriction bearings. For example, after five years of service, clearances of up to 1.5-2.0 mm were formed as a result of pressing-in between the outer rings of the bearings and their housings in the roller tables of the blooming mill of the "Azovstal" works. These clearances give rise to shock loads and cause the destruction of the outer rings and rollers of bearings. In addition, this adversely affects the correct mating of bevel gears, causing their rapid wear.

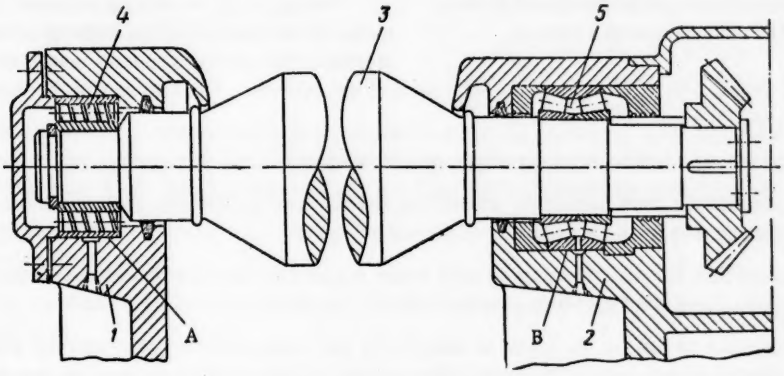


Fig. 1. General view of mill table roller: 1) bearing housing; 2) housing of reducing gear; 3) roller; 4, 5) roller bearings.

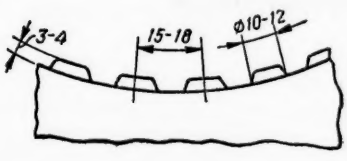


Fig. 2. Building up of bearing bores.

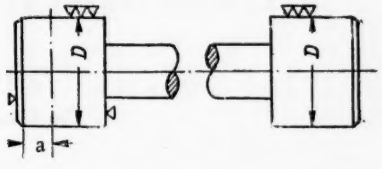


Fig. 3. Dummy shaft.

Figure 1 shows a general view of the roller unit of a mill table. The damaged places in the bearing bores are indicated by letters A and B.

The frames and housings of mill table reducing gears are heavy and expensive steel castings requiring complicated machining. Their replacement causes a prolonged stoppage of the rolling mill (12-15 days), since it is connected with some work on the foundations. It is not possible to bore the housings and to fit adapter bushes without dismantling the frames. The building-up of worn surfaces by welding, followed by grinding to a gage with an abrasive block, also fails to produce satisfactory results, because the distortion of the frame can destroy the alignment of pairs of bearings. Apart from that, it is difficult to obtain with this method the degree of accuracy required in mounting antifriction bearings.

Taking into account all these factors, the "Azovstal" technicians have evolved a new repair method: instead of building up the entire damaged surface, they deposit only small circular patches 10-12 mm in diameter and

3-4 mm high. For the positioning of these patches a checker pattern was adopted, with a distance between the built-up surfaces of 15-18 mm (Fig. 2). High-quality steel electrodes of not over 3 mm diameter are used.

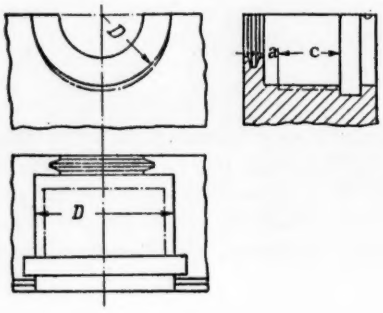


Fig. 4. Bearing bore. Portion to be machined is indicated by dotted line. a) Undamaged portion.

The patches are ground by means of a portable grinding device incorporating an abrasive disc of a slightly smaller diameter than that of the cylindrical surface being machined. The accuracy of machining is checked by a special "dummy shaft" (Fig. 3), the outer cylindrical surfaces of which are accurately machined in one setup. The cylinder D corresponds in size to the bearing bore and is a sliding fit in it. The cylinders of the dummy shaft are simultaneously introduced into the bearing bores of the same mill table roller. The grinding is continued until the dummy shaft has reached the undamaged portions, a (Fig. 4), of both housings.

Owing to the depositing of metal in small-area spots, no deformation of the housing occurs. On completion of the work the contact area between the outer ring of the bearing and its bore is 35-40% of the total area of the cylinder. The hardness of the deposited layer must be slightly higher than that of the housing.

8-10 hours are required for the overhaul of one pair of bearings.

Taking into account the time needed for assembling and dismantling the unit, such repairs can be carried out during the regular monthly 16-hour overhauls of the rolling mill.

Experience shows that the roller housings of mill tables repaired by the spot-depositing method, as well as the bearings themselves, have been operating satisfactorily for two years.

Similar methods can be used in the repair of other bulky and costly reducing gear housings with antifriction or sliding bearings used in metal works. This will lead to a considerable extension of their service life.

TEXTOLITE–SPONGE BEARINGS FOR ROLLING MILLS

P. I. Kovalev

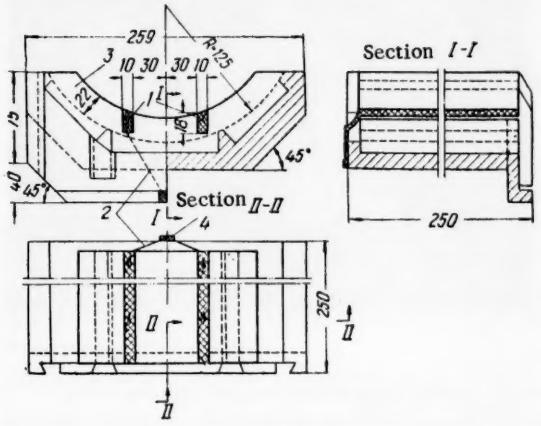
The Sulin Metal Works

At present, extensive use is being made in rolling mills of textolite bearings combined and pressed in one piece. If a sufficient amount of cooling water is available, then the service life of these bearings depends to a considerable extent on the hardness and temperature of the water and also on the degree to which the roll necks have been damaged by stray currents.

In order to increase the life of textolite bearings, thick lubricants are used and special protecting devices and electricity sources are installed. However, all these methods have substantial short-comings, such as considerable consumption of lubricants and complexity of installation.

At our works, in the blooming section of the "250" rolling mill, in which the short life of the textolite bearings caused frequent stoppages, a new textolite–sponge bearing was designed and constructed. It consists (see figure) of a textolite bush into which strips of sponge iron, impregnated with cylinder oil, are pressed.

These strips are joined by means of metal connections which also connect them with the casing and consequently with the housing of the rolling mill, thus enabling the stray currents to escape to earth; the oil pressed out from the sponge iron forms a thin film on the roll neck.



Textolite–sponge bearing. 1) Strip of sponge iron; 2) metal connections; 3) textolite bush; 4) welding joint.

For one bearing, 800 g of sponge iron is needed, the cost of 1 kg of this material being 1 ruble, 56 kop.

The testing of this bearing during one year of service showed that its cost is twice as high as that of an ordinary textolite bearing. During the most difficult summer period, the textolite–sponge bearings were in operation in the blooming mill for up to 1000 hot hours, while the life of the textolite bearings was 300-450 hours; the frequent replacement of bearings caused nonproductive stoppages and the waste of costly textolite.

The bearings with sponge iron are made as follows: selected roll scale taken from the mill is passed through a 1-mm mesh sieve and then reduced by the usual method adopted by the metal industry of this country. We ourselves made the sponge in this works.

After sintering, the surface of the sponge is cleaned and the sponge forged on a 150-ton friction press until it has reached a density of 4.0 g/cm^3. From the material thus produced, 10-mm wide strips are made on a planing machine; their thickness corresponds to the permissible wear of the bearing and their length – to the bearing length. Then the strips are boiled in cylinder oil (GOST 1841-51) for three hours and subsequently put into cold oil and stored until they are needed for assembly.

The strips are driven by means of a cover plate and hammer, into grooves of corresponding dimensions machined in the textolite bearing.

The strips are then connected to one another and to the body of the casing by arc welding, using for this purpose a 3-mm wire.

The observations made on the operation of the textolite–sponge bearings show that these bearings are most effective when the roll necks have to be cooled by warm hard water. The sponge does not serve as the load-carrying part of the bearing and it was found that for highest efficiency their area should be about 5% of the whole bearing area and the angle they form with the vertical axis, about 25°.

IMPROVED OPERATION OF PIPE-THREADING DIES

I. A. Gurin

Head of the Metal-Cutting Laboratory at the K. Libknekht Works

The special pipe-threading dies used in tube-rolling mills manufacturing drive pipes for the petroleum industry are very complicated, accurate, and expensive mechanisms.

TN4K, TN6K, TN8K, TN13K, and TN16K type pipe-threading dies are used with special machines, and machine the pipe to size and cut the taper thread on its end, by means of combined circular chasers, in a single operation (Fig. 1).

The cooling lubricant usually employed is sulfofrezol, which is fed through the machine spindle and holes in the die to a number of nozzles directed on the chasers. These holes are placed at an angle to ensure a more reliable removal of chips. As the pipes are threaded without previously turning them to size, small bits of scale removed by the chasers during threading sometimes get into the die together with chips. As a result the dies are

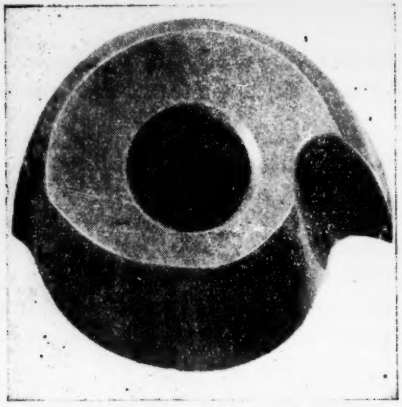


Fig. 1. Circular pipe-threading chaser.

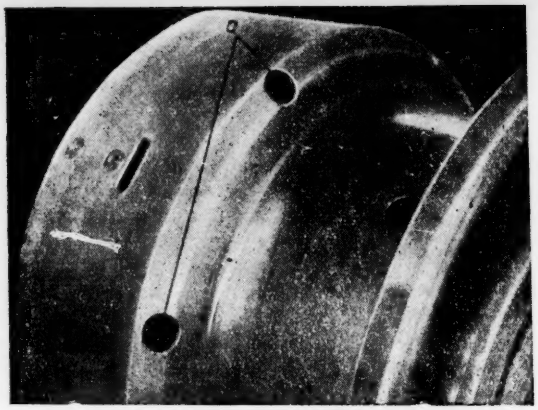


Fig. 2. Holes provided in the pipe-threading die for removal of chips.

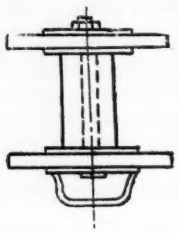


Fig. 3. Stopper for plugging the pipe during thread cutting.

choked and this renders the accuracy and finish of the thread unstable and in the event of a complete blockage leads to a stoppage of work. In such cases the die must be removed and dismantled and all its moving parts washed.

The replacement and resetting of the die require about 2 hours. The MIZ works, which make the pipe-threading dies, recommend in their operating instructions the regular dismantling and cleaning of dies (after 30 shifts of continuous operation). However, the die is often blocked before it has finished even one shift, because the coolant is supplied only under chasers while behind them the chips accumulate inside the sliding sleeve.

At our works, in order to improve the removal of chips, a number of holes were drilled in the body of the threading die along its circumference (Fig. 2). This die was in operation without a thorough cleaning for two months, or about 150 shifts; inspection showed that there was no accumulation of chips of damage to the tool. After that such holes were made in all dies, with the result that any blocking, and the stoppages it caused, was entirely eliminated. During two years of operation on no single occasion was the cleaning of the die necessary, apart from regular maintenance.

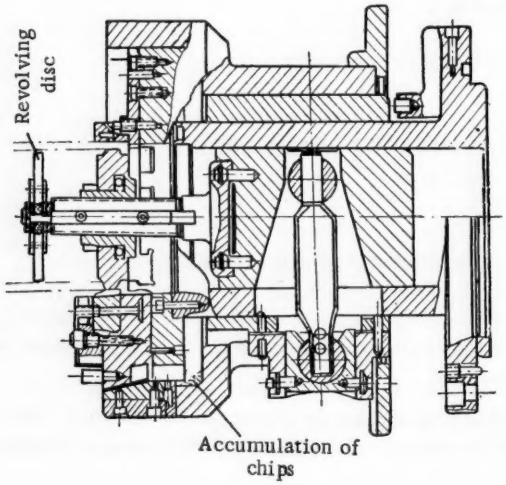


Fig. 4. The die with protective revolving rubber disc.

At present the dies are only cleaned when they are removed from the machine when changing to another diameter. The number of cleanings was reduced by a third.

The cooling liquid finds its way inside the pipe, thus increasing the coolant consumption. In order to prevent the coolant from getting too far into the pipe, a "stopper" (consisting of two rubber discs weighing about 5 kg, see Fig. 3) was used. This was introduced and removed by the operator; the operation took 8-10 sec. In order to improve the working conditions of the operator, the two discs were replaced by one, which is fixed to a center of shaft on a freely rotating sleeve (Fig. 4).

These measures enabled an increase to be made in the output of a battery of 6 machines of 150-160 tons per month.

NEW ORGANIZATION OF WORK AND PRODUCTION IN THE ROLLING AND HARDWARE DEPARTMENT

T. F. Koval

Deputy Head of the Work and Production Organization Laboratory at the Stalin Metal Works

The rolling and hardware department of our works manufactures galvanized hardware and painted and partly nickel-plated metal beds. These articles are made by the flow-production method, and the manufacturing process is broken up into separate, very simple operations which enable considerable use to be made of the division of labor.

Under these conditions the work of the operators is interconnected; this means that the fixed output rate must be the same for the whole crew, and it is expressed by the number of articles accepted by the inspection department during a shift.

In the rolling and hardware department the output rates were fixed separately for each operation and even for their elements. Under these circumstances the fixing of individual output rates led to disproportion and irregularity in the progress of operations; the production rate was actually determined by the operation requiring most time to complete. The transfer of operators, in case of emergency from one operation to another involved a reduction in their individual output and drop in earnings, and the mobility of the labor force within a shift was restricted.

In addition, the use of individual fixed output rates in mass production makes it impossible to ensure an accurate assessment of the quantity and quality of the completed work. The assessment of the actual output by the section or gang foremen was a difficult long job. Individual output and piece-work rates give rise to differences and anomalies in the earnings of workers of different trades and qualifications in the same crew. For example, a 3rd-class driller in the bed section engaged in a single operation earned 1300 rubles in one month, while a 6th-class assembly fitter in the same section earned 995 rubles and a 7th-class maintenance engineer, 730 rubles.

Collective fixed output (piece-work) rates weld the crew into a single unit, strengthen work discipline, cut down losses in working time and stimulate each member of the crew to work in close conformity with instructions in order to avoid rejects and second-grade production during subsequent operations. Such a method of output fixing ensures an accurate assessment of the quality and quantity of the finished products and renders the assessment of production considerably simpler.

In order to use the working time in the best possible way, the crew must be composed as a single unit and its foreman given wide powers, since he is responsible for the work of the whole team. The crew foreman can make changes in the allocation of work (even while it is in progress) to the individual members.

In order to avoid the equalization of wages, the maximum wage rate specified in the lists of grades and qualifications for a particular trade is awarded only to those members of the crew who are able to perform several operations. Workers who are able to perform only one or two operations are placed one or two classes lower.

Work on Hourly Schedule

Section: Galvanizing of hardware, crew foreman _____

for _____ shift _____ 195 _____

Hours	Buckets, no.					Bowls, no.					Stoppages and their causes
	scheduled	pledge of the shift	actually made			scheduled	pledge of the shift	actually made			
			1st grade	2nd grade	rejects			1st grade	2nd grade	rejects	
1											
2											
3											
Total:											

Note.: 1. The pledge regarding hourly output is made by the shift. Stoppages and their causes are entered by the crew foreman. 2. Actual output during each hour is entered by the inspector.

In order to ensure that the crews are financially interested in the quality of the articles produced and in the creation of a necessary reserve at the end of the shift, the actual shift output of crews must be determined by dividing the 24-hour output by the amount of work done by each shift (crew). The amount of work accomplished by a crew is expressed by means of a point system which takes into account the number of articles produced, the amount of labor these articles require, and the quantity of unfinished work at the end of each shift.

If, for example, an articles takes 0.9 man-hours to make and is allocated one point,then an unfinished job of 0.81 man-hours in the next to last operation left for the next shift, must be rated at 0.9 points and the preceding unfinished job of 0.72 man-hours will be given 0.8 points, etc.

The procedure used in taking over the work by the new shift must be in accordance with the relevant regulations, and the amount of unfinished work in each operation must each time be rated in points. In the case of nonfulfillment all or part of the points for good order and unfinished work are awarded to the shift which makes good the short-coming.

The work of the galvanized hardware section in the rolling and hardware department was not satisfactory. In order to improve the organization of work and production, a detailed time schedule, also containing the hourly schedule output, was worked out and put into operation in February, 1955.

The schedule was based on a planned hourly output and on pledges made by the shift before starting work (see table).

As a result of introducing the new scheme, the labor productivity rose by 20-30%. It was also found that a further output increase in galvanized iron hardware was prevented by the method of organization of work in the section in which each member of the crew was given his individual operation target while the shift (crew) had its own schedule for each operation; this meant that each worker in the section was financially interested only in the results of his own work.

The introduction to the galvanized hardware section of the new organization and wage scheme enabled the rolling and hardware department to attain a high degree of uniformity and regularity in its work, accompanied by high output figures. In the first month of the operation of the new scheme, the production of galvanized hardware increased over the preceding month by 74.4%; the productivity of labor rose by 68.1% and the average earnings of workers by 17.2%. The rejects fell to a third and the cost of production by 31.2%. After lagging behind for a long time, the galvanized hardware section fulfilled the plan by 103.3% for the first time.

In March, 1956, the new organization of work and production was introduced in the entire bed section.

At present the rolling and hardware department regularly fulfills and overfulfills the production plan in galvanized hardware and beds if the supply of materials is maintained at the normal level.

The output of buckets, bowls, etc. (galvanized and painted), increased in 1956, compared with 1955 by 17.8%, and of beds by 6.9%. This includes partly nickel-plated beds, the output of which went up 3.6 times. Second-grade articles and rejects were considerably reduced. The productivity of labor increased by 11.8% and earnings by 5.6%.

In 1956 the department made a profit of 155 thousand rubles (in 1955 there was a loss of about 3 million rubles).

EXPERIENCE OF INNOVATORS

THE WORK OF SOAKING PIT FOREMEN

Engineers Ya. P. Karmazin and A. L. Staroselsky

The Petrovsky Works

The highly efficient operation of blooming mills at our works is only possible if the operation of the rolling mill is closely coordinated with the operation of the soaking pits in the rail and sleeper department.

The reduction of stoppages due to the shortage of hot metal and the increase in the output of the pits achieved in recent years (see Table 1) were the results of: the introduction of the most up-to-date methods of heating the metal, the implementation of an improved system of supplying metal from the melting shops, an improved design of the pits, and a better heating technique.

TABLE 1

Data on the Operation of Soaking Pits

Years	Stoppages due to shortage of hot metal, in hrs	Output of the blooming mill, %
1952	—	100.0
1953	441.3	111.1
1954	220.3	115.9
1955	197.0	132.6
1956 (1st quarter)	12.3	142.1

The soaking plant of the blooming mill consists of three groups of recuperator pits, each of which has two multi-ingot pit holes; and a regenerative group, divided into 36 sections, for single ingots (see figure). The pits are served by three overhead tongs cranes. Each pit hole has a cover which is handled by a floor crane.

The output of the soaking pits is slightly lower than that of the blooming mill. However, by proper organization, this gap can be considerably reduced. The highly efficient operation of the soaking pits is largely due to the precise and skillful work of the foremen in charge of the pits.

The data of a time study were used to compile a time schedule for the operation of the cranes. Examination of these schedules enabled the methods of work used by the pit foremen to be developed.

Table 2 shows that the overhead cranes are in operation 52-74% of the working time and idle — 12-40%. This indicates the existence of a considerable reserve in the working time of the cranes.

Efficient Employment of Cranes

A good pit foreman fixes the order in which the cranes are withdrawn for preventive inspection in such a way that the charging and discharging of ingots and the cleaning of the pit chambers is completed during the first hours of the shift.

Taking into account the state of readiness of the metal at the end of the first hour, pit foreman Z. D. Klimenko withdraws for preventive inspection first No. 3 and No. 20 cranes, and then No. 2 crane. This enables work to be started simultaneously with two cranes after a half-hour pause. During the pause comrade Klimenko employs the cranes still in use for moving the ingots inside the pit holes and for other work needed for the efficient operation of the plant during the early hours of the shift.

The equipment of the soaking plant is best used when all Bessemer steel is treated in the regenerative pits and all hot and cold open-hearth steel in the recuperative pits. This method (used by foreman I. I. Khmel and K. A. Koshevoy) results in a sharp reduction of crane runs and leads to their better utilization. No. 2 crane takes

TABLE 2

Time Balance of Cranes

Elements of working time	Use of shift time by pit foremen							
	hr-min				%			
	Khmel	Klyuchko	Klimenko	Koshevoi	Khmel	Klyuchko	Klimenko	Koshevoi
No. 2 crane								
Main work	5—10	5—24	5—22	5—56	64.6	67.5	67.0	74.1
Additional operations	0—41	0—27	0—22	0—11	8.5	5.6	4.6	2.3
Preparatory and concluding operations	0—21	0—38	1—11	0—46	4.4	7.9	14.8	9.6
Stoppages	1—48	1—31	1—05	1—07	22.5	19.0	13.6	14.0
Total	8—00	8—00	8—00	8—00	100.0	100.0	100.0	100.0
No. 3 crane								
Main	5—16	4—41	5—01	5—18	65.8	58.5	62.8	66.2
Additional operations	0—37	0—33	0—29	1—08	7.7	6.9	6.0	14.2
Preparatory and concluding operations	0—30	1—47	0—48	0—40	6.3	22.3	10.0	8.3
Stoppages	1—37	0—59	1—42	0—54	20.2	12.3	21.2	11.3
Total	8—00	8—00	8—00	8—00	100.0	100.0	100.0	100.0
No. 20 crane								
Main work	5—00	4—52	2—34	4—09	62.5	60.7	54.9	51.9
Addition operations	0—06	—	0—03	0—04	1.3	—	0.6	0.8
Preparatory and concluding operations	1—13	—	1—04	0—57	15.2	—	13.3	11.9
Stoppages	1—41	3—08	2—19	2—50	21.0	39.3	31.2	35.4
Total	8—00	8—00	8—00	8—00	100.0	100.0	100.0	100.0

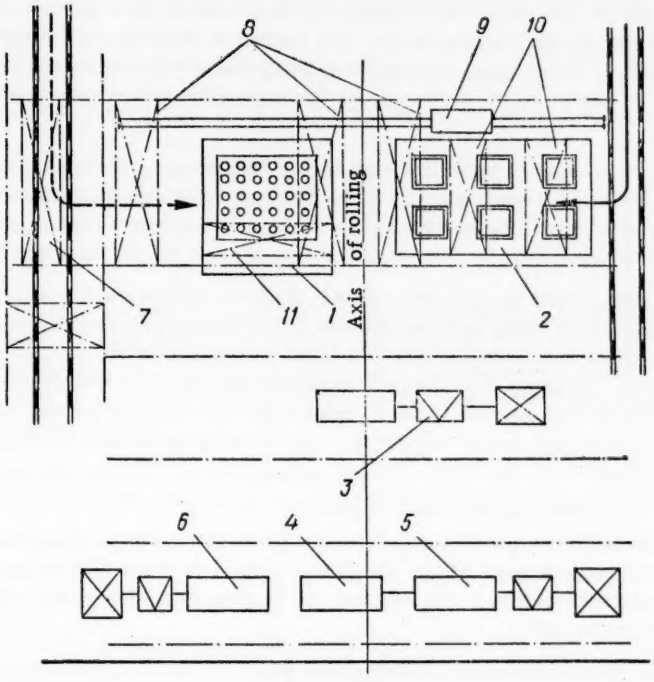
the ingots from the buggy and also removes them from the regenerative pits; No. 3 crane removes the ingots from the regenerative and recuperative pits; and No. 20 crane charges the recuperative pits only.

In order to reduce the runs of No. 20 crane in charging cold metal at the north side of the platform, Z. D. Klimenko moves the buggies with metal to the tracks nearest to the pits.

At the recuperative pits it is better first to remove the hot ingots and then to charge the new ingots in a north to south direction (first groups I and II, and then group III pits). This method eliminates the mutual interference of cranes. After the ingots of the pits in group III have been removed, No. 3 crane begins to discharge ingots from the regenerative pits and No. 2 crane to fill new ingots into the pit holes, which method again eliminates the mutual interference of cranes. In charging the group III recuperative pits, No. 20 crane is used.

Pit foreman K. A. Koshevoi and I. I. Klyuchko lower the fresh ingots into the same pit holes of the regenerative pit as those from which hot ingots have been taken. This enables the number of operations to be halved. The number of operations performed by the gantry crane is also reduced.

In the operation of overhead cranes, frequent pauses occur between the discharging of the ingots from various pit holes. Such pauses were necessary to replace the cores, lubricate the crane tongs, and to give instructions to crane operators regarding the order of removing the ingots. Pit foreman I. I. Khmel avoids these stoppages by preparing the second crane before the discharging of the preceding hole is completed.



General layout of the rail and sleeper department. 1) Regenerative group of pits; 2) recuperative groups of pits; 3) blooming mill; 4) roughing stand of the "800" mill; 5) blanking stand of the "800" mill; 6) finishing stand of the "800" mill; 7) stripping crane; 8) overhead cranes; 9) ingot buggy; 10) floor cranes; 11) cover crane. The continuous arrow indicates the flow of open-hearth steel; the dotted arrow the flow of Bessemer steel.

During the withdrawal of No. 20 crane for regular overhauls, which last for 8-12 hours, all work at the soaking pits is performed by two cranes, No. 2 and No. 3. On such occasions pit foreman comrade Khmel puts the cranes on specified work: No. 2 crane is allocated to the regenerative pits and No. 3 crane to the recuperative pits. In order to reduce the number of operations carried out by No. 2 crane, the ingots are removed from the regenerative pits only when metal is available to recharge these pit holes.

The efficient operation of soaking pit cranes is greatly facilitated by close cooperation between the pit foremen and the operators of all overhead and three-operation cranes.

The rail and sleeper department has two stripping sections. The control of the cranes of the soaking pit section is facilitated by two selector links for communication between the drivers of the three-operation cranes and the soaking pit foreman, and between the operators of overhead cranes and the foreman. These links enable the stripping crane operators to inform well in advance the duty control officers of the department and the pit foreman of the work the cranes are performing and of the amount of stock available in the section. Using the selector, the pit foreman instructs the crane operators as to when the stripping of ingots is to begin and how many ingots must be prepared for charging into the pits. The selector is also used to give instructions to the locomotive drivers and guards engaged in the transit of ingots from the melting shops.

The cleaning of the hearths of the recuperative pits and their charging with coke breeze occupies 1.2% of the total operating time of pit holes and 8-15% of the working time of No. 20 crane.

An improvement in the use of the recuperative pits can be achieved by increasing the intervals between subsequent cleanings and by cutting the time needed for cleaning and filling-in the coke breeze.

Earlier, the cleaning and filling of each chamber was done after four ingot charges. Now, on the suggestion of pit foreman I. I. Khmel, the pit holes are cleaned and filled after 5-7 charges, according to the condition of the hearth. In addition, not all the coke breeze is filled into the pit hole at once but half of it after cleaning and another half after the first charge has been put in. This method of cleaning and filling-in of the coke breeze increases the operation time of the pit holes, reduces the consumption of coke breeze and improves the heating of the bottom portion of the ingot, because of the smaller thickness of the coke-breeze layer during the heating of the first charge.

So as not to reduce the number of ingots in the pit during the cleaning and fillint of pit holes, foreman K. A. Koshevoi arranges these operations in such a manner that they coincide with the removal and charging of ingots from and into the regenerative pit. He inspects the chamber hearth before each cleaning and if he finds in it even a small amount of liquid slag, he gives the order first to clean the tap holes and then the whole hearth.

In order to cut the time needed for cleaning, comrade Koshevoi applies the following procedure: if No. 20 crane is engaged in the removal of ingots from the chamber to be cleaned, he orders the operator of No. 3 crane to continue discharging from the moment when only 2-3 ingots are left, while No. 20 crane picks up the shovel and approaches the chamber. As soon as No. 3 crane removes the last ingot, workers, on the instruction of the foreman, open the tap holes and the operator of No. 20 crane begins the cleaning process. In this way the pause between the removal of the last ingot and the beginning of the cleaning operation is eliminated.

Regular Operation of All Stands of the Mill

The bar produced in the blooming mill is transferred to the rail and sleeper mill located behind the former. This mill consists of three stands arranged in line. The blanking stand on which tube and section blanks are rolled is to the left (from the direction of rolling); the roughing and finishing stands for rolling railroad and crane rails, sleepers, and channels are on the right.

The operation of the mills is sometimes held up by the slow work of the auxiliary sections: the mechanized cooling plant to which is passed the stock which has been rolled in the blanking stand of the rail and sleeper mill, and the hot racks which take the output of the roughing and finishing stands of the mill. They are often filled to capacity and hold up the operation of the stand and the blooming mill. Therefore, pit foreman Z. D. Klimenko takes into account the outputs in each particular type of material of the blooming and rail and sleeper mills when he supplies material to the blooming mill. He pays special attention to the alternate supply of round and square blanks, since the rolling of large quantities of either of these leads to a rapid filling of the cooling beds.

The availability of hot metal is the necessary prerequisite for alternate rolling of rounds and squares. If no material is prepared, comrade Klimenko moves some of the ingots from the recuperative to the regenerative pits, thus speeding up the heating of the metal remaining in the pits.

Metal Heating Procedure

In charging and discharging ingots Z. D. Klimenko opens the covers of the recuperative pit holes only partly, thus considerably reducing the heat loss. If, due to a delay in the supply of hot stock, a pit hole remains empty for several minutes, comrade Klimenko uses this time for preheating the chamber. Such preheating is particularly desirable after cleaning the hole, or the first filling of coke breeze.

When sufficient hot stock is available, Z. D. Klimenko issues the ingot for rolling and puts the new ingot into the same pit hole.

If in the recuperative pits, four ingots are heated in a horizontal position, then K. A. Koshevoi turns them through 180°. This facilitates uniform heating and, what is of particular importance, enables the avoidance of overheating or burning the ingot sides facing the flame.

If there is a delay in the supply of hot ingots from the side pit holes of the regenerative pits, K. A. Koshevoi moves these ingots into other regenerative pit holes and puts ingots of the fresh heat into the empty holes. Such a method eliminates the burning of ingots in the first row of pit holes and enables the thermal load and the temperature in the regenerative pits to be maintained at a constant level.

The introduction of progressive methods developed by the soaking pit foremen results in a considerable improvement of the intensity of use of the heating plants and cranes and in an increase of 5-6% in the output of the blooming mill.

SCHOOLS OF ADVANCED EXPERIENCE

STUDY OF PRACTICES IN THE PRODUCTION OF RAILROAD RAILS

A. A. Slinko

Ukrainian Scientific Research Institute of Metals

An interworks school for the study of experience in the production of railroad rails took place from November 15 to December 15, 1956, at the Kuznetsk and Nizhne-Tagil Metallurgical Combines and at the "Azovstal" Works. The workers of the Dzerzhinsk Works and research workers of the Ukrainian Scientific Research Institute of Metals also took part in the work of the school. Members of the course were heads of plants (shops) or their deputies, foremen, rolling mill and other operators.

The participants were divided into two groups: the first studied mainly the technology of heating and rolling and the equipment of the mills; the second studied thermal treatment, finishing and the quality of rails.

The course members heard lectures by deputy heads of plants, laboratory research workers and workers of rail design bureaus on technology of production and design of rails and on the results of scientific research works regarding the improvement of rail quality.

Some data showing the characteristics of the rail rolling mills where the school was working, are given in Table 1 and the economical production indices of these mills are given in Table 2.

TABLE 1

Technical Characteristics of Rail Rolling Mills

Works	Billet cross section	No. and type of heating furnace	Fuel type (calorific value, cal/m^3)	Electric motors		Main grades
				mill	capacity, HP	
KMC	320 x 330	Three chamber furnaces, Siemens type	Blast furnace gas (900)	900-800	4250-6200	Rails R-43; R-50 Structural beam Nos. 18; 20; 22; 24; 30; 36; 45; 55; 60
				Finishing stand	1750	Channel beam Nos. 18; 20; 22; 24; 30 Backing for rails R-50; R-65 Mine props, square billets
NTMC	300 x 320	Two holding and two chamber furnaces	Coke oven and blast furnace gas mixture (1500-2000)	Mill 900 Mill 800	5000 6200	Rails R-38; R-54; R-50 Structural beam Nos. 27; 30; 40; 55; Z 310
					2500	Channel beam Nos. 20; 30 Tractor shoe Tube billets
"Azovstal"	270 x 280 300 x 300	Three holding furnaces	Coke oven and blast furnace gas mixture (1800-2000)	Mill 900 Mill 800	5000 6000	Rails R-50; R-65 Structural beam Nos. 30; 36; 40-k; 45; 50; 55
				Finishing stand	2500	Channel beam Nos. 24; 30 Backing for rails R-50 Grooved poles ShK-1; Shp-1; square billets

TABLE 2

Main Economical Production Indices of the Rail-Structural Mills

Item	KMC		NTMC		"Azovstal"	
	1955	10 mos, 1956	1955	10 mos, 1956	1955	10 mos, 1956
Output of serviceable products,* %	100.0	100.0	97.9	98.4	112.5	104.0
Output in busy time, t	164.3	167.5	160.2	170.4	180.3	182.7
Idling, % of nominal time	26.6	22.4	25.0	24.0	23.3	24.1
Rejects, % of serviceable products	0.221	0.159	0.39	0.31	1.02	0.99
Metal consumption, m	1.058	1.055	1.071	1.077	1.067	1.073
Conventional fuel consumption, kg/t	24.4	24.7	60.0	55.7	85.5	79.4
Electric power consumption, KN·hr/t	40.4	48.5	39.6	38.1	48.7	50.9
Operating cost, rubles/t	30.12	29.58	60.53	56.67	65.05	62.57
Operating efficiency of a worker, t	97.3	107.4	75.6	75.9	85.4	86.7

* Output of the rail-structural mill of the KMC is taken as 100%.

Kuznetsk Metallurgical Combine

The course members noted that the Kuznetsk mill operators have achieved a high temperature of ingots on charging into the soaking pits (860°C on the average) and a good quality of ingot surface.

In the Combine, the rail steel is poured into molds with "floating" ceramic hot top and this method promotes the production of ingots with a clean surface, satisfactory macrostructure and without cooling fissures. The adoption of floating hot tops resulted in an increase of 1st grade rail by 2-3%. At the present time, experiments are being carried out in the KMC (Kuznetsk Metallurgical Combine) on the adoption of a rectangular rail ingot of 8 tons. Extensive work is being carried out in the Combine regarding the development and on the adoption of so-called diagonal rail rolling, where the formation of the base and the top of the rail takes place at the expense of the corners of the ingot thus increasing by 1.4 times the metal working on the center of the section.

At the same time, while noting the positive factors in the work of the rail plant of the KMC, the course members also observed several substantial short-comings.

The roll changing on mill 800 is done by an out-of-date method and this prolongs the idlings of the mills (in the Nizhne-Tagil and the "Azovstal" Works roll changing with a stand has been adopted). Frequent breakages of cast iron couplings also cause prolonged mill idlings.

The rails, prior to entering the stamping press, are tilted manually, although the installation of tilting plates involves neither technical difficulties nor any considerable expenditure.

There is a large stock of rolls in the plant, but there is still no mechanized storage; rolls are stored incorrectly. The interworks school recommended several measures with a view to eliminating the short-comings in the work of the plant, and fixed the time by which these measures should be completed. In particular, for the improvement of rail quality, the interworks school recommended an increase in the height of the initial billet before the first cutting roll and a reduction of the widening in the rail-shaping rolls to a minimum value.

Nizhne-Tagil Metallurgical Combine

By its layout and the construction of the equipment, the rail-structural mill of this Combine shows advantageous differences from other similar mills. In the construction of the mill, a full mechanization, to be followed later by the automation of the manufacturing process, has been taken into account. The plant is provided with five isothermal furnaces for thermal treatment of rails.

In the course of the development of these furnaces and the establishment of the optimum conditions in the thermal treatment of rails, the construction of the fire roofs has been somewhat modified. In order to facilitate the control of the temperature conditions of the furnace, each burner has been provided with a U-type manometer. The brickwork of the baffle has been raised by 65 mm. Owing to these measures, the variation of the temperature along the furnace has been reduced to 50°C and the actual capacity of the furnace has reached the designed capacity.

In order to investigate the conditions of flake formation, research work was carried out on the artificial increase of flake susceptibility of steel by means of saturating liquid steel with hydrogen. It was established that the flake susceptibility depends on the duration of the hydrogen treatment, the hydrogen pressure and the height of a given section in the ingot. The rails of the top end of ingot have the highest susceptibility to flake formation.

On the basis of this investigation the optimum time of rail treatment in furnaces (2 hours) and the temperature in the furnaces (600 ± 25°C) was established. In addition, it was established that isothermal exposure increases the plastic properties of the metal.

In the development of rail end hardening with high frequency current, some work was carried out on design improvement of the mechanisms of the hardening chambers and on the establishment of hardening technology. At the present time the electrical equipment is fully automated; its operating cycle is synchronized with the operating cycle of other finishing machines. The hardness and the thickness of the hardened layer conform with GOST specificiations.

The roll design for R-50 rails differs in some respects from the design in other works. There are three T-passes and five flat passes, instead of four T-passes and six flat passes as is the practice of the KMC. Investigations into the effect of the design of passes on the quality of rail surface have shown that the cracks and fissures on rails are, in the majority of cases, the suspension and thermal cracks in the ingot. For the reduction of the depth of cracks in the rails the important factor is a high deformation along the edge and not the height of the grooving edge.

One of the substantial short-comings of the rail-structural plant of the NTMC (Nizhne-Tagil Metallurgical Combine) is the out-of-date method of heating cold billets in holding furnaces and the subsequent transfer of billets to chamber furnaces. Itcomplicates the process and prolongs the time of heating. Moreover, there is no heating schedule for the holding furnaces, so that the metal is frequently overheated and the rail quality lowered.

Having the best equipped mill, rail finishing plant and thermal treatment department, the Nizhne-Tagil Combine still shows the lowest productivity results (see Table 2). This can be explained by the fact that the rail production in this mill constitutes about 30% of the total output. For the remainder of the time the equipment of the rail finishing plant and the isothermal furnaces stand idle.

Automatic recording of the quantity of rolled materials has been introduced in the plant but it has not been brought to completion: the cutting of metal is not watched over and a great number of short pieces are counted as long ones. Consequently, the over-consumption of metal in the plant amounted to 4900 tons for 10 months of 1956. The school recommended that the experience of the Kuznetsk Combine with regard to the recording and cutting of metal and the accounting between plants should be made use of.

In order to raise the rail quality and to reduce the amount of faulty products, the school recommended the Combine: a) to study and utilize the experience of the steel making plant of the KMC; b) to increase the rail ingot temperature to 850°C on charging into the heating furnaces of the blooming mill; c) to carry out the dressing of cold rail billets before charging them into the holding furnaces; d) to discontinue the rolling of rails from cold rail steel ingots.

The "Azovstal" Works

The personnel of the rail-structural mill of this Works has achieved good productive indices. In spite of some unfavorable circumstances (for instance, frequent roll changing caused by the poor operation of the open-hearth furnace plant and by substantial short-comings in the management planning) the plant produces considerably more rolled material than the rail-structural mills of the KMC and the NTMC, and has the highest time operating efficiency (see Table 2).

A serious short-coming of the rail-structural mill of the "Azovstal" Works is the high quantity of faulty (rejects) and second-grade products. The main fault in the product is the hair-line cracks. After a study of the causes of crack and fissure formation in the phosphorus-containing material, showing that defects of the open-hearth plant production constitute 59%, the method of rail-steel making has been improved and mold R-9 has been replaced by new R-6/U ones. The curvature radius between the edges in the new mold is reduced to 66 mm in the upper part and to 45 mm in the lower, the edges are rounded (curvature 15 mm).

A new rail steel ingot of 9.7 tons has been adopted in the works. It has made possible a considerable increase in the output capacity of the pouring floor of the open-hearth furnaces, an increase in the percentage of the hot charge of the rail metal and, consequently, an increase in the output of first-grade rails. Tests showed that the rails made from heavy ingot are not inferior regarding quality and mechanical properties, to the rails made from 6.6 tons ingot. Moreover, a considerable increase in the operating efficiency of the soaking pits and of the blooming mill is achieved; metal consumption per ton of rails is reduced by 2.3%.

The interworks school has noted a low durability of the finishing stand rolls. Thus, in the "Azovstal" Works, 500-600 tons of rails is rolled with one set of rolls, whereas in the NTMC 1200-1300 tons of rails is rolled, although both mills use rolls made by the Lutuginsk Works. In order to increase the life of the rolls the school recommended the removal of the scale on the finishing and pre-finishing stands prior to the rail entering the rolls; in addition it is necessary to carry out experiments and to test the effect of sea water on the durability of rolls by applying fresh water for cooling the finishing stand.

For the improvement of the quality of railroad rails the interworks school suggested an increase in the ingot temperature, on charging into the furnace, to 820°C (from 770°C), an increase in the amount of hot charge in the holding furnaces to 70%, and that the shaping of the head and base of the rail from the narrow edges of ingot should be carried out on mill 900.

* * *

For an improvement in the operation of all rail-structural mills of the Soviet Union the school proposed:

1. To organize the production of high-durability, low-carbon, cast rolls of "Adamit" and "Fenix" type on the new plant of the Lutuginsk Works.

2. For the proper control of rails, to arrange with MPS the preparation and introduction of acceptance forms for rails according to the technically justified instructions of the KMC, making possible a considerably better utilization of working rolls.

3. For the reduction of faulty products in rolling to recommend in all works the use of rejected blooms for the adjustment of mills after roll changing.

4. To note substantial defects in the existing roll-guiding machine of UZTM design (inconvenience and difficulty on roll changing, unsatisfactory service of bronze bearings not allowing the use of the full capacity of the equipment).

To request the design organizations to develop a new, better design for roll-guiding machines, calculated for use on R-75 rails and structural beam No. 80.

5. To note that the application of "floating" hot tops in the KMC eliminates lateral shrinkage cracks in ingots and increases the output of first-grade rails by 2-3%. It is desirable to build plants for making "floating" hot tops in all the works which produce rails.

6. For the establishment of a uniform system in the determination of the temperature of ingots on charging into the heating furnaces, it is expedient to request all works to measure the temperature of the ingot $^1/_3$ of the way from the lower part.

OUTSTANDING METALLURGISTS

GEORGII AGRICOLA

Four hundred years ago a book "On Mining and Metallurgy" was published, comprising the knowledge of mining and metallurgy in that period. The author of this work was German scientist Georgii Bayer, writing under the pen name Agricola. He lived and worked at the time when capitalist relations began to develop inside the feudal system.

Agricola was born on March 24, 1494, in a small town Glauhav, in Saxony. In 1514, after leaving the Latin school in Zwickau he came to Leipzig and entered the university.

In 1552, Agricola began to lecture at Leipzig University and, striving to extend his knowledge, studied medical science intensively. Two years later he undertook – with a view to further studies – a journey to Italy, where he studied in Bologna and Padua – two main scientific centers of the country.

In a short time Agricola gained the higher academic degree of Doctor of Medicine and then Doctor of Philosophy.

In 1526, Agricola returned to Germany. Wishing to study the occupational diseases of miners closely, he went to Joachimstahl (now Jachimow in Czechoslovakia). During his medical studies he learned that in ancient times Greeks and Romans used minerals and metals for treatment of illnesses. Therefore, Agricola decided to study mineralogy with a view to reintroducing these methods of treatment.

The Jachimow mining region was famous for rich deposits of many valuable minerals and was one of the largest mining centers in Europe. On obtaining the position of town physician in Jachimow, Agricola began, side by side with the medical practice, to study geology and mineralogy. His all-round education and ability to work enabled him with the help of Jachimow specialists, to master quickly the principles of metallurgy and mining.

In Jachimow, Agricola wrote his first book on mining: "Bermannus, or About Mining and Metallurgy." In this work, published in 1530 in Basle there is given a short history of mining, of mines and their equipment and history of some mining centers known at that time. In addition he described some valuable minerals.

In Jachimow, Agricola started to prepare his major work dedicated to the problems of the exploitation of mines and the extraction of metals.

In 1533, in Basle, was published Agricola's work "Five Books on Measures and Weights." The measure and weight systems used in different countries were discussed in his work. The book was of great importance, as, at that time, there was no uniform system of measures and Agricola's work gave the relations between weights and measures of different countries as well as a comparison with the ancient ones.

In the book "The Nature of Minerals" the classifications of valuable minerals proposed by other scientists were discussed. Agricola extended these classifications considerably and made a new classification which was in use until the 18th century.

Finally, in his main work "Mining and Metallurgy" which was the basic text for practical workers for more

two hundred years, Agricola summarized the experience of mining and metallurgy. This work consisted of 12 books (or rather chapters). In it Agricola shows the necessity for the development of mining and gives an account of ore prospecting methods. The methods recommended by Agricola are based on criteria giving prospects of mineral deposits. At that time, the results of prospecting for useful minerals depended on chance circumstances, and, therefore, many a prejudice and superstition was current among miners, the most wide-spread being the belief in the "magic twig" or divining rod. Such a twig with a forked end was usually cut from the walnut tree. For "prospecting," this twig was held by the fork with two hands, the fingers pointing to heaven and the end of the rod being lifted slightly. If the prospector came over a vein the twig would, supposedly, immediately turn downwards pointing at the right spot. And, of course, there were numerous reservations explaining the ineffectiveness of the twig in one case or another.

Agricola denounced this mystic twig. He wrote that " . . . a true mining prospector, whom we should like to regard as a solid and serious man, will not use a magic twig, for any reasonable man, even to the slightest extent versed in nature, understands that this twig will not help him at all, but, on the other hand, he has at his disposal, as I have pointed out above, natural indications of ore deposits and he should be guided by these criteria."

The book gives a description of methods of metal smelting from ores, and of the bloomery process of iron making in use at that time. Into a special furnace, about 1 m high and of square cross section of 1.42 m side, a crucible 0.283 m high and 0.42 m wide was placed. Charcoal and a mixture of crused ore and unslaked lime were charged in layers into the crucible. Air was supplied with bellows. The smelting lasted 8-12 hours. Then a lump of low-carbon, sponge-like iron (bloom), was removed from the crucible. It was forged under a water-powered hammer, cut into 5-6 parts which subsequently were hammer-forged into bars. Thus soft wrought iron was obtained.

Agricola's book was of great importance. This is convincingly proved by its several editions in various languages. After the first edition of the book which was published in 1556, a year after the author's death, there were three editions in Latin and several editions in Italian, German and other languages.

Agricola's works were well-known in Russia. V. N. Tatishchev, V. I. Gennin, I. A. Shlatter, M. V. Lomonosov and others studied the works of Agricola and further developed the science and technology of mining.

Georgii Agricola has an honored place among the workers of world science and technology. His works promoted the establishment of geology and mineralogy as independent sciences, and formulated the first guiding principles of mining and metallurgy.

FROM THE HISTORY OF TECHNOLOGY

DEVELOPMENT OF WROUGHT IRON PRODUCTION

V. B. Yakovlev

Wrought iron is the iron obtained in a paste-like form by bloomery, puddling or similar methods. Iron in these processes crystallizes on transition from liquid to solid state. The cavities between iron particles are filled with slag, which is relatively easily forced out in the process of forging. After the slag removal, the lump of iron is again brought to red heat ("welding heat") and forged. The iron particles are welded together in the process of forging and form a solid piece of iron.

Wrought iron was obtained either directly by "raw-blast furnace" method or by the working of pig iron in bloomery or puddling processes. Wrought iron has been known to man since ancient times as a material from which castings can be made. As early as 600 years B.C. iron castings were made in China. Blast furnaces, however, were not known yet and pig iron was obtained by simple ore smelting with charcoal. As a rule, pig iron contained a large amount of phosphorus which, probably, was specially added. This method did not spread to other countries, not even in Russia where the iron-making art was learned from the Chinese. The Russian word "chuhun" (pig iron) derives probably from the Chinese "chzhuhun" (smelter) or "chzhugendi" (poured). In most countries the development of pig iron and other forms of iron production occurred in a different direction: the production of pig iron in high blast furnaces with subsequent iron and steel-making.

In the course of the blast furnaces process improvement, it became necessary to purify the obtained product of contaminations, as with the increased height of the furnaces and prolonged residence of the materials in the furnaces, conditions were provided for higher accumulation of carbon in iron and for the reduction of oxides of other elements which occur as impurities in iron alloys. Therefore, side by side with the blast furnaces process, there developed metal-working processes resulting in the first method of pig iron treatment – the so-called bloomery process.

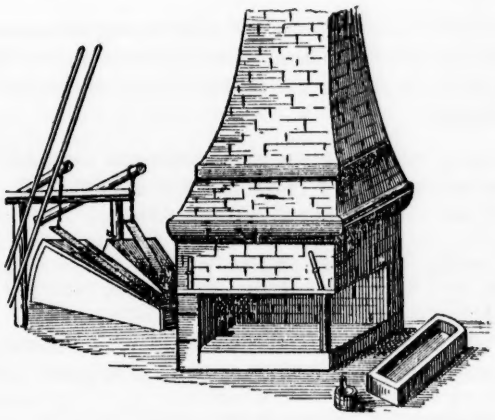


Fig. 1. Refinery hearth (bloomery).

In this process pig iron was charged into a furnace, so-called bloomery (Fig. 1), not unlike a blacksmith's hearth. Near the furnace, a hammer with a water-driven wheel was usually installed.

About 90 bloomery methods are known, each of which was used in certain localities. They differed in the way in which the bloom was obtained. In addition, a group of methods is known in which the iron cake (bloom) was produced in one furnace and the pieces of bloom were treated in another. The main method in this group is the so-called Walloon method.

The blast furnace process with subsequent pig iron treatment, developed approximately at the end of the 14th and the beginning of the 15th century. The process expanded very slowly.

The first blast furnace works in Russia began operating near Tula (Gorodishche Works) in 1637, and there were also refinery hearths (bloomeries). Their practice spread at first in the center of Russia and then extended to the Urals.

Toward the beginning of the 18th century the bloomery refining process of pig iron finally replaced the primitive iron smelting and it was the main method of iron making in Russia until the second half of the 19th century.

The techniques of the bloomery process underwent several changes in the course of development. Initially, the refinery hearth was very similar to a blacksmith's hearth. The only difference was that the working space of the refinery hearth was made in the form of a box. Subsequently, the refinery hearth was modified. Under one flue, two working chambers instead of one were installed (Fig. 2), the weight and the design of the hammer were also changed. The bellows, however, underwent the most pronounced changes. New designs and principles of operation of air bellows were appearing in the blast furnace process and were introduced without changes in the refinery process.

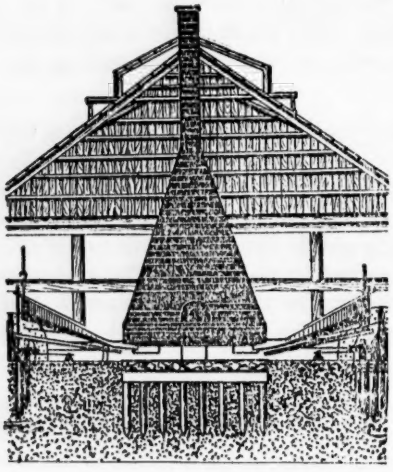


Fig. 2. Two refinery hearths under one flue.

Air bellows were operated by a water-driven wheel.

Initially, the bellows were triangular, made of leather, then they were replaced by wooden ones, but still triangular. The triangular bellows were gradually replaced by piston blowers, at first wooden box-shaped, then wooden cylindrical, and finally made of cast iron. These improvements affected the design of refinery works and water consumption, water shortage frequently occurring. Thus, one refinery hearth was served with leather and wooden bellows (two bellows for each hearth) which were actuated by one water-driven wheel. Later on the same wheel was driving an equipment consisting of four or six piston blowers which served six or eight refinery hearths.

All these changes made possible a considerable increase of furnace (hearth) output and a reduction of charcoal consumption. While at the end of the 17th century, the daily output of a hearth constituted 10-15 puds (1 pud = 16.38 kg), and more than 11 puds of charcoal were used up for the production of 1 pud of iron, at the beginning of the 19th century the daily output of a hearth reached 25-30, sometimes even 48 puds and fuel consumption fell to 2.5-4.0 puds of charcoal per one pud of iron.

The iron produced in the refinery hearth was nonuniform in composition: the part which during the process was near the blast had very few impurities whereas at the other end there were many more impurities because of the nonuniform oxidation atmosphere in the furnace. Therefore, it was not possible to obtain a large quantity of metal of a comparatively uniform composition in a refinery hearth.

At the end of the 17th and the beginning of the 18th century, Russian metallurgists learned how to produce in the refinery furnace not only soft iron but also carbon-containing metal, i. e., steel. At the end of the 18th century a good quality metal was obtained from bloom iron by the cementation and crucible methods.

Ancient Russian metallurgists knew how to impart hardness to iron tools by carbonizing them in charcoal. But later on this process was not used and was nearly forgotten. In 1722, the French physicist Reamuir described a method of iron plate carbonizing in fairly large furnaces. After some time this method began to be widely utilized in various countries, including Russia. However, the quality of carbonized steel was low as the cementation of iron plates was not uniform and many blisters frequently appeared on the surface of the steel plate.

Carbonized steel was used as raw material in the crucible process of high-grade steel production. This method, devised by an English horologist, Huntsman, consisted of melting carbonized steel with the addition of charcoal and crushed glass in a hermetically-sealed crucible. The production of crucible steel was practiced in many countries but since the steel output in this process was limited, the crucible steel could not replace cheap refined iron. The refinery process was replaced by the puddling process.

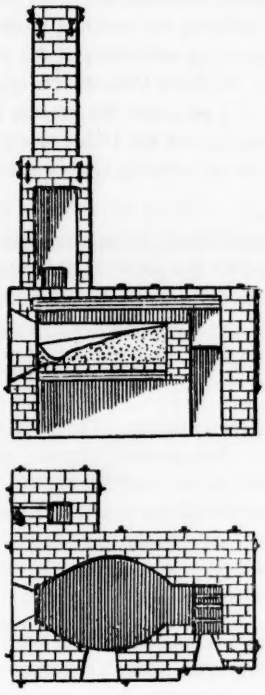


Fig. 3. Reverberatory furnace for pig iron refining.

At the end of the 18th century most of the blast furnaces in Britain were using coke and hence the output of pig iron increased. The bloomery refinery process required large quantities of charcoal and this hampered the development of the metallurgical industry in the country. It was necessary to find a new and more efficient method of pig iron refining with mineral fuel.

Reverberatory furnaces, fired with coal had already been used in some places for the secondary melting of pig iron. Therefore, the puddling process was developed in a relatively short time. In 1762, D. Robek obtained a patent for a process similar to the puddling process. In 1766, the Brothers Cranedge built a reverberatory furnace and made in it wrought iron from pig iron. In 1783, P. Onions proposed his design for a puddling furnace.

Henry Cort (1740-1800) had the biggest success. He introduced, in 1784, the puddling process consisting of the following:

Pig iron (with the addition of iron slag, scale and scrap) was charged into a hot reverberatory ("air") furnace and was heated until it all but melted. The metal was stirred with an iron bar until it began to transform into a pasty spongy state and gradually form iron balls. These balls were then removed from the furnace to the hammer, under which the slag was expelled and the iron was cut into lumps. After a secondary heating to "welding heat" in the same reverberatory furnace, the lumps were rolled by means of rolls into plates.

This form of puddling process was very widely used in England and other countries. The first puddling furnaces were lined with refractory brick and had river sand floors. Therefore there was only a little slag on puddling and the process was called "dry puddling." Pig iron was subjected to preliminary refining in refinery furnaces where it became white. These furnaces were similar to the bloomery furnaces.

However, not all kinds of pig iron were suitable for refining by the "dry puddling" process. It was especially difficult to remove phosphorus, which constituted a substantial impurity in the pig iron produced in England, Germany, France and other countries. Therefore, experiments carried out in some countries were not successful. This was the case in Russia, where experiments were made in the Pozhevsk Works in 1817, and then in the Nizhne-Tagil Works in 1826.

In 1816, Rogers suggested, instead of a brick furnace bottom which lasted for about a week of operation, putting a metal bottom (wrought or cast iron plates). This improved the efficiency of the furnace. In many countries then the furnace bottom was made of iron slags or mill scale, by introducing it in layers of 5.0-7.5 cm. This improvement promoted the wide use of the puddling process.

The adoption of the puddling process had its effect on the improvements in the old refinery process. The so-called "kontuaz" method was introduced and then the Lancashire hearth was developed. In the first one the pig iron was melted in the upper part of an enclosed hearth and drops of metal flowing over the hot charcoal were freed from impurities under the action of the air stream. In the Lancashire hearth, which was also enclosed, the air for the blast was heated with the flue gases and so some fuel economy was effected.

In 1837, the puddling process was introduced in the Kamsko-Votkinsk Works. Instead of coal, wood was used as fuel. This is understandable, considering the enormous forest wealth of the Urals. Coal was adopted for the puddling process considerably later, at the time when the metallurgical industry in the South developed.

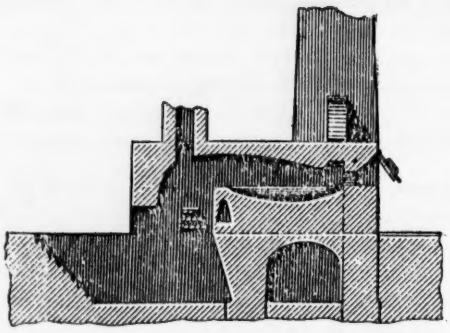


Fig. 4. English puddling furnace (1800).

The expansion of the puddling industry in Russia was very fast. As early as 1860, the iron output from the puddling furnaces exceeded that from the old refinery furnaces. Puddling and welding furnaces improved and the operating efficiency of the puddling process increased. While in 1836 the charge of a puddling furnace was 7-11 puds and the process lasted 2 hours, in the second half of the 19th century the charge reached 35-36 puds and refining time was reduced to 1.5 hour.

The gas reverberatory furnace designed by Siemens was also used for the puddling process. The economy of fuel and an increased efficiency contributed to the existence of the Siemens gas puddling furnaces for some time even after the introduction of the Bessemer converter and open-hearth furnace.

The quality of puddling iron is somewhat better than that of the old refinery process. The puddling process allows for the production of several grades of iron: according to the fracture – fine grained, fibrous; according to purity – single-welded, double-welded, etc. Single-welded iron is obtained in the puddling furnace and then welded and rolled between the rolls. The plate produced is cut in two, a few pieces are laid into a packet, heated to welding heat in the welding reverberatory furnace and again rolled into a plate. In this way double-welded iron is obtained. Its quality is improved as the impurities are partly removed under the action of air at high temperature.

Wrought iron is very resistant to corrosion. Hence, the puddling process was used for a long time for the production of material with anti-corrosion properties and good welding properties. Thus, even at the beginning of the 20th century, ship anchors were made only from puddling iron.

The puddling process is the final stage in the development of wrought iron production. With the introduction of open-hearth furnace and the Bessemer converter, began the large scale production of cast steel.

METALLURGIST IN ENGLISH TRANSLATION

August, 1957

TABLE OF CONTENTS

	Page	Russ. Page
1. Plant Laboratories in 1957. N. I. Beda, I. I. Barnatsky, M. T. Bulsky, F. F. Sviridenko, N. T. Berilov and N. P. Zhetvin	493	1
2. An Extensive Mining and Metallurgical Region. A Scientific Conference on the Problems of the Turgai Regional Economic Complex. M. Darishev	498	5
3. Increasing the Smelting Rate of Blast Furnaces. M. Ya. Ostroukhov	501	7
4. Dust-Removing Equipment for Sintering Plants. A. V. Sheleketin and N. S. Karpushinsky	504	10
5. Defects in the Plan for Supplying Sinter to Blast-Furnace Bunkers by Conveyors. V. A. Karasik	506	12
6. Fused Stone Slabs – a Wear-Resistant Protective Material. V. K. Petrichenko.	508	14
Steel-Melting Production		
7. Ways of Increasing the Productivity of Open-Hearth Plants. Ya. A. Shneerov and A. G. Kotin	512	18
8. The Thermal Process Taking Place in an Open-Hearth Furnace During Oxygen Melting. V. T. Sladkoshteev and G. A. Podolskaya.	516	21
9. New Method of Making Hearths of Basic Open-Hearth Furnaces. M. S. Sokolov and P. P. Semenenko	518	23
10. Improved Blocks of Open-Hearth Furnaces. A. P. Klyucherov and L. V. Makogonov	522	26
Rolled Product and Tube Production		
11. The Rolling of a Side-Ring Section of Reduced Weight. S. G. Terentyev.	524	28
12. Turning Rolls for Continuous Blooming Mills. A.A. Tulupov and Tsui Fun.	526	30
13. Repair of Mill Table Beds. V. F. Ivanov.	529	32
14. Textolite – Sponge Bearings for Rolling Mills. P. I. Kovalev	530	34
15. Improved Operation of Pipe-Threading Dies. I. A. Gurin.	531	35
16. New Organization of Work and Production in the Rolling and Hardware Department. T. F. Koval	533	36
Experience of Innovators		
17. The Work of Soaking Pit Foremen. Ya. P. Karmazin and A. L. Staroselsky.	535	38
Schools of Advanced Experience		
18. Study of Practices in the Production of Railroad Rails. A. A. Slinko	539	41
Outstanding Metallurgists		
19. Georgii Agricola	543	44
From the History of Technology		
20. Development of Wrought Iron Production. V. B. Yakovlev	545	45

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosenergoizdat	State Power Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LEIIZhT	Leningrad Power Inst. of Railroad Engineering
LET	Leningrad Elec. Engr. School
LETI	Leningrad Electrotechnical Inst.
LETIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MEP	Ministry of Electrical Industry
MES	Ministry of Electrical Power Plants
MESEP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTI	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOE	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIEL	Central Scientific Research Elec. Engr. Lab.
TsNIEL-MES	Central Scientific Research Elec. Engr. Lab.–Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIESKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZEI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us. – Publisher.